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SURGICAL MEMOIRS

OF THE

WAR OF THE REBELLION.

COLLECTED AND PUBLISHED

BY THE

UNITED STATES SANITARY COMMISSION.

I.

ON THE WOUNDS OF BLOOD-VESSELS, TRAUMATIC HEMORRHAGE, TRAUMATIC ANEURISM, AND TRAUMATIC GANGRENE.

II.

ON THE SECONDARY TRAUMATIC LESIONS OF BONE: NAMELY, OSTEO-MYELITIS, PERIOSTITIS, OSTITIS, OSTEO-POROSIS, CARIES, AND NECROSIS.

III.

ON PYÆMIA.

BY

JOHN A. LIDELL, A. M., M. D.,

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EDITED BY

PROF. FRANK HASTINGS HAMILTON.

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EDITOR'S PREFACE.

THE several papers constituting this volume belong to a series of surgical essays and observations accumulated from the late war, and placed in my hands by the United States Sanitary Commission, with a request that I should select such as I thought most worthy, and arrange them for publication. In the performance of this somewhat delicate and responsible duty, I have been aided by the intelligent counsel of several members of the Commission: and after much unavoidable delay, it has been decided to publish, as a first installment, the valuable contributions of Dr. Lidell on "The Wounds of Blood-vessels, *et cætera*, the Traumatic Diseases of Bone, and Pyæmia;" which subjects, although anatomically and physiologically separate, have intimate pathological relations, and such as render it proper that they should be arranged in the same volume.

Embracing, as these papers do, all the more recent observations upon the topics discussed, with a vast amount of careful original research, they constitute complete and exhaustive treatises, which cannot but be acceptable to the Medical Profession. Nor can I doubt that they will be received as further proof of the good judgment of the Commission in the publication of these memoirs.

FRANK H. HAMILTON.

NEW YORK, *December* 4, 1869.

8973

AUTHOR'S PREFACE.

This book consists of three Sections. The first was written in the spring of 1866, the second in the preceding winter, and the third in the summer of that year. The second is, therefore, first in point of time. They were prepared as detached memoirs, but a considerable degree of interdependence, especially between the second and third, was unavoidable, and it is probable that this circumstance has now led to their publication in the present form.

Since these memoirs were written a considerable period of time (almost four years) has elapsed. In the fall of 1867, however, the Author was notified that they were about to be published, and accordingly he then made a very careful revision of Section First, and a tolerably thorough revision of Sections Second and Third. But the day of publication was deferred, and when at last the proof-sheets came to hand circumstances beyond his control allowed but little to be done to them aside from correcting simply verbal and typographical errors. If, then, any later views, or any more recent contributions on the subjects of this volume have not received adequate mention at his hands, this circumstance may afford the explanation.

Section First is largely devoted to the important subject of traumatic hemorrhage. Its pathological and surgical relations are attentively considered. Its several

varieties, their causes, consequences, and treatment, are carefully discussed in the light of pathological and clinical experience. One variety, namely, parenchymatous hemorrhage is comparatively new, at least in English medical literature. The interesting and important topic of battle-field hemorrhage is carefully considered in its various practical relations. Of the wounds of blood-vessels the author has endeavored to give a more systematic, thorough, and complete account than any before presented. It seemed necessary to do so in order to comprehend the subject of primary hemorrhage. Of traumatic aneurism he has treated at considerable length, and especially with regard to its pathology and cure. He has also attempted to show the preferableness of the "old operation" for the relief of traumatic aneurism, when practicable, to that of Hunter, and also to point out its limitations. He hopes that his discussion of the subject will prove satisfactory. Of gangrene as a consequence of wounds and injuries of blood-vessels he has endeavored to present a fuller account than any which has preceded it, and especially of its practical relations.

Section Second is entirely devoted to a consideration of the secondary traumatic lesions of bone in the enlarged or physiological sense of the term. They are osteo-myelitis, periostitis, ostitis, osteo-porosis (medullization), caries, and necrosis. A chapter is devoted to each of them except osteo-porosis. It is discussed in connection with osteo-myelitis, ostitis, and caries. The precedence has been given to osteo-myelitis for reasons which are stated in the introduction to Section Second. It is not necessary to reproduce them here. Dry gangrene of bone is called necrosis. There is, however, another form of osteal gangrene, namely, the wet or mephitic, described in this sec-

tion. It is believed that this subject is quite new. Another comparatively new subject is the spontaneous separation of the epiphyses of the long bones of the lower extremity in consequence of osteo-myelitis. A case is related, and whatever is known concerning this disorder is also presented to the reader.

Section Third treats of pyæmia. The author has endeavored to discuss its clinical and practical relations with especial care. In a surgical point of view pyæmia is a subject of vast importance. The remarkable relationship which exists between suppurative osteo-myelitis and this disease is clearly shown. It is believed that this subject also is comparatively new. The conclusions which the author has been led to adopt concerning pyæmia, as given at the end of the section, are presented as affording about the only satisfactory or complete explanation of its varied phenomena, in the present state of our knowledge. Some of them, especially those relating to the pyæmic *contagium*, are obviously provisional, and are given rather as affording a starting point for fresh investigation, than on account of their proven truth.

The author has endeavored to discuss his subjects as briefly as seemed consistent with clearness and with their great importance. He also wishes here to state that he first learned to know how important these subjects really are while he had charge of the Stanton U. S. Army General Hospital, and that he there began to collect the personal observations, the clinical histories, and the post-mortem records which are set forth in the following pages. He has also endeavored to write from nature. This book is, therefore, essentially clinical in character. Most of the cases have never before been published; some have already appeared in the medical journals; a few have been taken

from books of acknowledged authority, but all, it is believed, have some bearing of importance on the subjects in connection with which they are related. The original cases either occurred in the author's practice, or were furnished him by his professional friends, or were placed in his hands by the United States Sanitary Commission as contributions received by them to the Surgical History of the War. In every instance the contributor's name is given in connection with his case.

On returning to New York at the close of the war the author strongly felt the need of two things pertaining to the subject matter of what now constitutes the second section of this book: *first*, he wanted actual proof that osteo-myelitis occurs frequently in civil as well as in military practice, and that the laws of its development are the same in both civil and military life; *second*, he needed drawings made from nature to illustrate its anatomical character, course, and consequences. With the assistance of his professional friends and at the expense of considerable time and labor on his own part he has succeeded in supplying these important needs. To Dr. Hamilton of the Bellevue Hospital, to Dr. Gouley of the Bellevue and St. Vincent's Hospital, and to Dr. Buck of the New York and St. Luke's Hospital, he is indebted for opportunity to study the subject of osteo-myelitis and kindred disorders as they occur in civil practice, and for valuable assistance in obtaining, or for permission to use the morbid specimens represented in the wood-cuts and chromo-lithographs which constitute the illustrations of this volume.

To Dr. Elisha Harris and to Dr. Van Buren he owes that counsel and assistance without which the construction of this book would have been impossible.

To Dr. Gouley he is also indebted for most important

aid in conducting the microscopical examinations which are detailed in the following pages.

To Dr. James E. Steel he is under obligation for the specimens of necrosis from which Figures 4 and 5 were taken.

To Dr. G. A. Quinby credit is due for furnishing a translation of Pirogoff's views on the subject matter of Section Second, which the author received, in manuscript, through the hands of Dr. Van Buren, and of which he has made free use in that section.

If this book shall add anything to the domain of human knowledge, if it shall serve to account for any of the untoward results of surgical operations which before seemed strange and unaccounted for, and especially if it shall enable us to obviate any of these untoward results, then it has not been written in vain. And to the considerate notice of the intelligent reader this volume, notwithstanding its many faults, is now respectfully commended by

THE AUTHOR.

NEW YORK, *January 1st*, 1870.

UNITED STATES SANITARY COMMISSION.

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§ These gentlemen never took their seats.
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of the Bad Consequences of employing the Persulphate of Iron and Pressure to restrain Hemorrhage from Large Arteries are shown by this Case. — These Agents proved insufficient to control the Bleeding. — In such Cases we should not waste Valuable Time in trying Inefficient Agents. — Other Evils resulting from the Use of Ferri Persulph. and Pressure stated. — A Case of Gunshot Wound of the Thigh near its Middle severing the Femoral Artery; Vessel tied both proximally and distally at End of Twenty-four Hours; Secondary Hemorrhage Six Days after Injury; it was controlled by Pressure; Gangrene; Death on Eleventh Day; Autopsy; Femoral Vein also found to be ligated; Distal Ligature of Artery had separated; the Secondary Bleeding occurred from the Distal Orifice; Bad Consequences of Pressure in this Case. — Consequences of tying the Femoral Vein in this Case; it probably assisted in producing the Consecutive Gangrene. — The Primary Hemorrhage was considerable, and although it did not prove immediately fatal, it in Reality contributed much to that Issue. — A Case of Gunshot Wound of the Femoral Artery near the Middle of the Thigh contributed by Dr. Clendenin; Hemorrhage very profuse; Vessel ligated on the Spot; but the Patient had lost so much Blood that he died Twenty-eight Hours afterwards; the Autopsy showed that the Femoral Artery was completely divided, and that the Femoral Vein was not injured. — Another Case of Gunshot Wound of the Femoral Artery near the Middle of the Thigh, contributed also by Dr. Clendenin; Hemorrhage very profuse, and the Patient died before he could be carried to the Field Hospital, a Distance of about One Mile. — Dr. Baylor's Case, in which the Femoral Artery was severed by a Minie Ball without Consecutive Hemorrhage. — Summary of the Foregoing Cases, Five in Number, in which the Femoral Artery was severed by Gunshot Projectiles. — Primary Hemorrhage slight in Two, considerable in One, and Fatal in Two Instances. — Secondary Hemorrhage occurred in Two Instances. — Consecutive Gangrene occurred in Two Instances. — All of them died; Two of Primary Hemorrhage; One of Exhaustion following Secondary Hemorrhage; One of Gangrene; and One of Secondary Hemorrhage and Gangrene. — Duration of the Cases severally stated. — A Case of Gunshot Wound of the Popliteal Artery, contributed by Dr. Clendenin; Hemorrhage at first Profuse, but it ceased spontaneously; Consecutive Gangrene of Foot and Leg; Amputation on Thirteenth Day after Injury; Recovery. — Another Case of Gunshot Wound of the Popliteal Artery mentioned by Dr. Clendenin. — A Case of Gunshot Wound severing the Popliteal Artery; Hemorrhage ceased spontaneously; Gangrene of Foot and Leg occurred in Four Days; Amputation and Death from Exhaustion on the Fifth Day afterwards. — Septæmia from the Gangrenous Leg occurred in this Case. — Primary Amputation should have been performed. — A Case of Gunshot Wound of the Knee-joint severing the Popliteal Artery. — Summary of Four Popliteal Artery Cases. — In all of them the Bleeding ceased spontaneously. — In Three of them Consecutive Gangrene is known to have occurred. — The Reasons for such a Result stated. — Two Patients died and Two were saved by Timely Amputation. — Next, Two Cases are related in which Gunshot Wounds severing the Posterior Tibial Artery were followed by Gangrene. — In both of them the Bleeding ceased spontaneously. — Gunshot Wounds of the Middle and Upper Thirds of the Leg which sever the Posterior Tibial Artery, are generally followed by Gangrene. — The Reasons for such a Result stated. — On Gunshot Wounds dividing the Axillary Artery, with Three Illustrative Cases. — Another Case also referred to. — Primary Hemorrhage generally does not prove fatal in Cases where the Axillary Artery is completely divided by Gunshot Projectiles. — The Bleeding generally ceases spontaneously in such Cases. — Summary of these Four Cases. — Consecutive Gangrene occurred in One Instance, Traumatic Aneurism in One Instance, both proving fatal, and the remaining Two Cases recovered. — On Gunshot Wounds dividing the Brachial Artery, with Three Illustrative Cases. — Two of them were contributed by Dr. Clendenin. — Summary of the Three Cases. — In all of them the Primary Bleeding stopped of itself. — In none of them did Gangrene occur. — Two recovered and One died of Pyæmia. — A Case of Gunshot Wound severing the Internal Mammary Artery, contributed by Dr. Clendenin. — Disastrous Consequences of Styptics and Pressure in this Case. — A Case in which the External Carotid Artery was probably severed by a Pistol-ball, contributed by Dr. Sanford B. Hunt, late Surgeon U. S. Volunteers. — The Hemorrhage was arrested by Digital Pressure applied in the Wound, and the Patient recovered. — Concerning the Value of Local Pressure for the Temporary Control of Certain Forms of Bleeding, and the Way in which it should be applied for such a Purpose. — General Sum-

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5. INCISED WOUNDS OF ARTERIES.

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CHAPTER FOURTH.

ON TRAUMATIC ANEURISM.

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CHAPTER FIFTH.

ON WOUNDS OF THE VEINS.

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EXPLANATION OF THE PLATES.[1]

PLATE FIRST.

Reduced one third.

THIS plate gives a representation of osteo-myelitis in the first stage; also of commencing gangrene of the marrow, endostosis, and periostosis. The specimen from which it was taken consists of the lower fragment of a femur which had been fractured by fire-arms ninety-eight days before. It has been split lengthwise and from before backwards with a saw. The surface of the section only is figured. The specimen is represented with its articular or knee-joint extremity uppermost, and consequently with its fractured end pointing downwards. The deep-red color which the marrow often assumes when it becomes sclerosed or carnified by the inflammatory process, is well shown. The dark-colored spot in the midst of the inflamed (red) medullary tissue represents a small slough, *i. e.*, gangrene of the marrow in an early stage. It was, doubtless, formed just before death.

The broken end of the specimen is rounded off. The fracture did not unite. The medullary canal at and for some distance from the place of fracture is filled, more or less completely, with new osseous tissue (endostosis) having a porous structure and a pale-red color. There is also a considerable deposit of new bone upon the exterior of the specimen (periostosis) extending from the place of fracture along the shaft some two or three inches. This periostosis and likewise the endostosis are distinctly shown in the plate.

About an inch from the broken end a hole is represented in the compact wall of the shaft, through which a small fragment of bone was driven into the medullary canal (marrow) when the casualty occurred.

The patient was treated at Bellevue Hospital, in the service of Drs. James R. Wood, Stephen Smith, and Frank H. Hamilton. Professor Hamilton had charge when death occurred.

Case X. David Suffern, aged forty-six, wounded by fire-arms, September 28, 1865; died January 4, 1866, of chronic pyæmia; pp. 319–321.

[1] NOTE. — The author is not responsible for the lettering of Plates 1, 4, 6, 8, and 9, because the proofs of these plates were not submitted to him for that purpose. He is, however, accountable for the lettering of Plates 2, 3, 5, 7, and 10, as it was done by him. But when he lettered Plates 3, 5, and 7, he was not aware that Plates 1, 4, 6, 8, and 9, were already finished. If he had been acquainted with this circumstance at that time, he would probably have pursued a different plan. It has seemed necessary to say thus much, in justice to the author, concerning this matter; and if any discrepancies shall be found to exist between the lettering of these plates and the text, he is obviously not accountable for them.

PLATE SECOND.

The specimen here represented consists of the upper fragment of a femur, which had sustained a gunshot fracture ninety-eight days before the death of the subject from which it was obtained. It has been cut in two, or rather it is represented as cut in two, in order to get it within the limits of the plate. It has also been split lengthwise with a saw in order to expose its interior to view. The lower fragment of the same bone is represented in Plate 1; but the disease is not nearly so far advanced in that part as it is in this.

F. Place of fracture, *i. e.*, the fractured end of the specimen; no attempt at union at this point; medullary canal open and allowing matter to escape freely from the medullary abscesses.

A, A. Place where the specimen is represented as cut in two.

S, S, S, S. Suppuration of the marrow; in the canal of the shaft the medullary tissue has undergone very extensive destruction, and the purulent matter forms collections of considerable size, which, however, communicate freely with each other; in the caput and cervix femoris, and throughout the upper end of the specimen generally, the medullary tissue has been transformed into pus to very great extent. This circumstance is well shown in the plate.

O, O. Ostitis; the compact tissue of the bone has become reddened by the inflammatory process.

P, P. Periostosis, of considerable extent.

Ph. An osteophyte, measuring two and three fourths inches long, two and one fourth inches wide, and three fourths of an inch thick. Externally it presents a dark color, from being covered over with some dried connective tissue. It served to unite in a partial or imperfect manner the fragments of the broken bone, which overlapped each other considerably, as generally happens in similar cases. This new osseous growth has been developed almost entirely from the connective tissue.

The patient was treated at Bellevue Hospital, in the service of Drs. James R. Wood, Stephen Smith, and Frank H. Hamilton. Professor Hamilton had charge at the close.

Case X. David Suffern, aged forty-six, wounded by fire-arms, September 28, 1865; died January 4, 1866, of chronic pyæmia; pp. 319–321.

PLATE THIRD.

Osteo-myelitis of right femur, following compound fracture, the result of railroad injury. Death occurred sixty-six days after the accident. The upper fragment of the broken bone is figured in the plate. It is represented as cut in two in order to get it within the limits of the plate. It

has been split lengthwise with a saw, and the surface of the section is in reality what is figured. The disease is in the first stage, *i. e.*, the marrow has become sclerosed, carnified, or hepatized through the agency of the inflammatory process. Above the place of fracture the inflamed marrow has a yellowish-red color, in the middle of the specimen it is bright-red, and at the upper end of the medullary canal it is dark-red, and even brown in spots. At the place of fracture, however, the marrow is mortified to small extent. It is probable that this gangrene occurred shortly before death. The compact tissue of the femur (shaft) is decidedly reddened in color or inflamed for several inches above the place of fracture, and elsewhere it is obviously more vascular than normal (ostitis). There is also extensive periostosis. It is well represented in the plate. There is, too, considerable endostosis, extending several inches above the place of fracture, but it is not and cannot be distinctly shown in the plate, on account of the pale-red color of the new osseous tissue itself.

R, *R*. Sclerosed, carnified, or hepatized marrow.

G. Gangrene of the marrow.

P, *P*. Periostosis.

O, *O*. Ostitis (secondary).

The patient was treated at St. Vincent's Hospital, New York, in the service of Drs. Voss and Gouley. Dr. Gouley had charge when death occurred.

Case XI. Michael Stack, aged twenty-five, injured by railroad cars, November 7, 1865; died January 12, 1866, of irritative fever and exhaustion; pp. 322–324.

PLATE FOURTH.

Reduced one third.

The pathological specimen represented by this plate consists of a knee joint and parts of the several bones which enter into the structure of this joint. The specimen has been split lengthwise and from before backwards with a saw. The surface of the section and the interior of the joint are figured. The patella remains attached to the tibia by its proper ligament; but it has been separated from the quadriceps extensor cruris muscle. Some tendinous fibres, however, which belong to that set of muscles, remain attached to the superior border of the patella. The portion of the femur that is represented consists of the lower fragment of a thigh-bone which had been broken by railroad injury sixty-six days before. The upper fragment of the same thigh-bone is represented in Plate 3. The medullary tissue of the lower fragment is moderately inflamed (first stage of osteo-myelitis), but the disease is not nearly so

nor so far advanced as it is in the upper fragment (see Plate 3).

The broken end of this, the lower fragment, is rounded off, not regularly, but obliquely, from behind forwards. The fracture did not unite.

The knee joint exhibits in a very striking manner some of the results of traumatic arthritis. It is undergoing bony anchylosis. The cartilage of incrustation has almost entirely disappeared from the condyles of the femur, the head of the tibia, and the patella; and its place is supplied by a thick layer of new, firm, deep-red granulations of bone. Thus, the head of the tibia and the patella are becoming fastened to the condyles of the femur, not by the intervention of new fibrous or cartilaginous tissue, but by new osseous tissue itself. The cartilage of incrustation appears to have been transformed directly into new osseous tissue. The joint does not contain any new connective nor any new cartilaginous tissue. The anchylosed bones have been torn apart, or separated by force, for the purpose of exposing the interior of the joint to view. The deep-red color of this part is well shown in the plate.

This specimen teaches a very important lesson in surgical pathology, for it shows us precisely how bony anchylosis is not unfrequently produced by inflammation of joints. It is scarcely necessary to state that this is not the only way in which true anchylosis may occur as a consequence of arthritis.

The patient was treated at St. Vincent's Hospital, New York, in the service of Drs. Voss and Gouley. Dr. Gouley had charge when death occurred.

Case XI. Michael Stack, aged twenty-five, injured November 7, 1865; died January 12, 1866, of irritative fever and exhaustion; pp. 322–324.

PLATE FIFTH.

The specimen represented in this plate consists of a stump-bone, resulting from amputation of the left arm, and invaded by osteo-myelitis. It has been opened lengthwise with a saw, and the surface of the section only is figured. The disease is in the first stage, namely, that of sclerosis, carnification, or hepatization. The coppery-red hue which the carnified marrow presented when the specimen was opened is accurately represented in the plate. The teat-like protrusion of the carnified marrow from the canal at the sawn end of the bone is likewise well shown in the plate. The dead-white color of necrosed bone is also well represented. The inflamed medullary tissue was very firm, almost flesh-like, in consistence. It retained the marks made by the saw-teeth while splitting the bone, even after it had been thoroughly scraped with a scalpel for the purpose of clearing off all the bone-dust, and this circumstance is well shown in the plate.

This patient was treated at Bellevue Hospital, in the service of Professor Hamilton.

Case XIV. William Dargen, aged twenty-eight, sustained amputation of left arm, December, 1865, for caries of elbow joint, the result of injury, and died on the seventh day afterwards of acute pyæmia; pp. 328–330.

PLATE SIXTH.

Osteo-myelitis in the second stage, *i. e.*, the stage of suppuration, is represented in this plate. The disease followed primary amputation of the arms (both) for traumatic cause. The operation was performed about five hours after the accident. Death occurred on the twentieth day afterwards. The specimen consists of the stump-bone taken from the left limb. It has been opened lengthwise with a saw, and the surface of the section only is figured in the plate. The disease is far advanced. A large medullary abscess has been formed. It is about three inches long, and full of dirty, greenish-yellow matter. It is surrounded by or imbedded in dark-red, sclerosed medullary tissue. It is well represented in the plate. The nipple-shaped protrusion of the tough, dark-red, sclerosed, carnified, or hepatized medullary tissue from the canal at the sawn end of the bone is also well shown in the plate. Above the abscess many small, isolated, ash-colored dots, located for the most part in the cancelli, are seen. They are minute abscesses, or distinct foci of suppuration.

The patient was treated at Bellevue Hospital, in the service of Professor Hamilton. The limb was amputated by the circular method.

Case XXIX. Tobias Dillon, aged twenty-four, injured by machinery, November 21, had both arms amputated five hours afterwards, and died of pyæmia, December 11, 1865; pp. 376–378.

The wounds of operation did well apparently until the end, although the patient had pyæmia, and died of it.

PLATE SEVENTH.

Reduced one third.

Osteo-myelitis of right humerus (stump-bone) following primary amputation performed in consequence of injuries, is represented in this plate — specimen sawed in two longitudinally — surface of section only figured. The disease is passing from the first into the second stage. Gangrene of the marrow also has occurred in the sclerosed part, where it borders upon the seat of suppuration. The gangrene is limited, and probably occurred just before death. But the medullary tissue of this stump-bone is, for the most part, in a state of sclerosis, carnification, or hepatization. At the sawn end, however, it is suppurating, and, a little above, it is gangrenous.

R. Sclerosed, carnified, or hepatized marrow (osteo-myelitis in first stage).

S. Suppurating marrow (osteo-myelitis in second stage).

G. Gangrenous marrow.

The specimen represented in this plate was obtained from the same subject as the specimen represented in Plate 6. He suffered primary amputation of both arms, as already stated. The left was cut off by the circular method, the right (the one mentioned above) by the double-flap method. Professor Hamilton performed the operations about five hours after the accident.

Case XXIX. Tobias Dillon, aged twenty-four, injured by machinery, November 21; died of pyæmia, December 11, 1865; pp. 376–378.

Notwithstanding the occurrence of pyæmia, the wounds of operation appeared to do well till the end.

PLATE EIGHTH.

This plate represents osteo-myelitis in the first stage; also endostosis, periostosis, and secondary ostitis. The specimen from which the plate was obtained consists of a portion of the left humerus (shaft), which had been fractured by railroad injury. There was no attempt at union. Six weeks after the accident, the arm was amputated a short distance below the surgical neck of the humerus. The specimen was taken from the amputated member, and consists of the portion of bone extending from the place of fracture to the place of amputation. It has been opened lengthwise with a saw, and the surface of the section only is figured. The marrow is in the first stage of the inflammatory process. It is sclerosed, carnified, or hepatized. The deep-red color thereof is beautifully shown in the plate.

The fractured end of the specimen points downwards. It is rounded off, and the medullary canal at this place is thoroughly occluded with new bone. Besides, there is copious endostosis, which also is beautifully shown in the plate. A large part, but not the whole of the endostosis, has a whitish, almost chalky look.

A considerable quantity of new osseous tissue has been formed upon the exterior of the specimen, near its fractured end. This periostosis is, to some extent, figured in the drawing.

A moderate amount of secondary ostitis was present in the compact tissue of the specimen at and near the place of fracture. This pathological state is rather imperfectly shown in the plate by the reddening of the compact osseous tissue at and near the place of fracture.

Case XLVIII. A young man, aged nineteen, sustained fracture of his left arm from railroad injury about the middle of October, had the limb amputated November 25, and died of pyæmia December 7, 1865; pp. 431–433.

Thus, on the twelfth day after the operation, the patient died of pyæmia. The next plate shows the morbid appearance which the stump-bone presented after death.

PLATE NINTH.

This plate represents osteo-myelitis in the second stage, or that of suppuration. The morbid specimen from which it was taken, is the stump-bone belonging to the case related in connection with the last plate. The specimen has been sawed in two lengthwise, and the surface of the section only is figured. The disease, as already stated, is in the second stage, or that of suppuration. Plate 8 represents the appearance and condition of the inflamed marrow at the time of amputation, and Plate 9 shows what progress the disease had made on the twelfth day afterwards. The medullary tissue of the stump-bone has become extensively destroyed by transformation into pus, and the medullary spaces or cancelli are extensively filled with dirty, ash-colored matter. This plate gives an excellent representation of the appearance which the interior of the specimen presented when it was first examined.

The patient was treated at the New York Hospital.

PLATE TENTH.

The specimen here represented, consists of the tibia of a young girl, aged eleven, which has been extensively destroyed in consequence of osteo-myelitis. It is represented as cut in two, in order to get it within the limits of the plate. It has also been split lengthwise with a saw, in order to expose its interior to view.

E. Superior epiphysis of tibia.

L. Lower end of tibia.

A, A. Place where the specimen is represented as cut in two.

S, S, S. Suppuration of the marrow. Two good-sized collections of purulent matter (abscesses) have been formed. That in the lower third of the bone has a somewhat leaden hue.

R, R. Red, sclerosed, carnified, or hepatized marrow.

N, N, N. Necrosed bone. Numerous (thirteen) fragments are distinctly shown. Most of them are small. Two, however, have a considerable size.

P. Periostosis.

The superior epiphysis itself presents a healthy appearance. The cartilage of conjunction, however, has been destroyed, or has disappeared, from having been transformed into new, soft, red, granulation tissue, through the agency of the inflammatory process. Thus the epiphysis has become separated from the diaphysis, and thus a false point of motion has been established. In the midst of this new, soft, red, granulation tissue, eight or ten small fragments of necrosed bone, which belong to the upper end of the shaft, are seen. Besides them two necrosis fragments, having

a much larger size, are shown a little below. The internal laminæ are necrosed more extensively than the external.

In this specimen, then, inflammation of the marrow resulting in suppuration, inflammation of the bone resulting in necrosis, and inflammation of the cartilage of conjunction resulting in the formation of new, soft, red, granulation tissue, are severally represented. The inflammation of the marrow, however, appears to have been the first to occur, because, among other reasons, some large medullary abscesses had had sufficient time to form.

The case occurred in the private practice of Dr. John Busteed. Professor Van Buren saw the patient in consultation with Dr. Busteed, and in the end amputated her leg at the knee joint, with a good result.

Case XLIX. A young girl, aged eleven; disease of near two months standing, and probably produced by a fall on the ice; exarticulation at the knee; recovery; pp. 435–437.

SECTION FIRST.

ON

THE WOUNDS OF BLOOD-VESSELS, TRAUMATIC HEMORRHAGE, TRAUMATIC ANEURISM, AND TRAUMATIC GANGRENE.

SECTION FIRST.

CHAPTER FIRST.

TRAUMATIC HEMORRHAGE.

Importance of the Subject in both a Practical and a Scientific Point of View. — Hemorrhage often alarms the Patient and sometimes the Surgeon. — What Qualifications the Surgeon should possess in order to treat Hemorrhage satisfactorily. — Classification of the Phenomena; (1.) the *Local*; (2.) the *Constitutional*. — Of the Local Phenomena. — Characteristics of Venous Hemorrhage. — Characteristics of Arterial Hemorrhage. — Phenomena of hemorrhage from the Distal Orifice of a Wounded Artery. — Of the Constitutional Phenomena of Hemorrhage. — Pallor, Faintness, Syncope. — Hemorrhagic Convulsions. — Hemorrhagic Coma. — Hemorrhagic Fever. — A Pinched or Shrunken Condition of the Face and Body produced by Hemorrhage when excessive. — Characteristics of Hemorrhagic Pallor, a peculiarly Blanched, Semi-transparent, Yellowish-white, Waxen Appearance. — Thus, the Constitutional Phenomena of Hemorrhage are well marked. — Classification of the various Forms of Traumatic Hemorrhage, and Definition (1.) of *Primary Hemorrhage*; (2.) of *Intermediary Hemorrhage*; (3.) of *Secondary Hemorrhage*; (4.) of *Parenchymatous Hemorrhage*. — The Discussion of Primary Hemorrhage naturally precedes that of the Other Forms. — The Phenomena and Consequences of Traumatic Hemorrhage are modified by the Size and Locality of the Wounded Vessel, by the Extent of the Breach in its Walls, by the Nature of the Breach itself, *e. g.*, whether it is an *Incised*, or a *Punctured*, or a *Lacerated*, or a *Contused*, or a *Gunshot Wound*. — In Warfare, Gunshot Wounds vastly predominate over all Other Kinds of Injury. — Bayonet and Sabre Wounds of comparatively very Rare Occurrence. — Statistics of British Army in Crimean War illustrating this point.

Importance of the subject.

THE *outflow of blood* which is produced by wounds and other forms of injury constitutes one of the most important of all the subjects that can engage the surgeon's attention. This topic possesses very great interest in a practical, as well as in a purely scientific point of view, since it is well known that traumatic hemorrhage *often* proves extremely detrimental to its victims, and, not unfrequently, destroys their lives with unlooked-for suddenness and rapidity. Indeed, it constitutes one of the most impressive causes of sudden death which is ever encountered in surgical practice. Besides, clinical experience has shown that loss of blood is, either *directly* or *indirectly*, the means of producing a fatal result, in a very considerable proportion of all the cases of injury which have a fatal termination. Hence it is that the surgeon, while planning or performing any of the operations pertaining to his art, takes especial pains to avoid the effusion of an unnecessary

quantity of blood, or even the needless endangering of such an effusion; and, while conducting the after-treatment, constantly keeps before his mind the possibility of the occurrence of hemorrhage, and adopts such a course in the management of the case as will, in his judgment, be most likely to prevent it.

Hemorrhage often alarms the patient, and sometimes the surgeon.

Hemorrhage often occasions great alarm to the patient. But few men are endowed with such stolidity as to permit them to behold their own life-current steadily flowing away, unmoved, especially if the stream be great. And even the surgeon is not suitably prepared to take part in such a scene, unless he is strengthened and fortified by a thorough knowledge of the means by which nature unaided effects the suppression of traumatic hemorrhage, together with all the various procedures which art can bring to the assistance of nature for the accomplishment of such a purpose, and, at the same time, has such a ready acquaintance with the anatomical structure of the parts involved in the hemorrhage, as will enable him to put in practice the procedures suggested by art with promptness, with neatness, with accuracy, and with despatch. If the surgeon does not possess these necessary qualifications, his patient is liable to suffer much in consequence of his deficiency. For if he be unacquainted with the method in which nature arrests traumatic hemorrhage, he will be likely to do harm by meddlesome interference; and if, on the other hand, he be ignorant of the resources of surgical art in the treatment of hemorrhage, or does not possess a thorough and ready knowledge of surgical anatomy, he will be likely either to allow his patient to die (if the case be a bad one) from want of appropriate surgical treatment, or to positively assist in producing a fatal result by the injudicious application of remedies, or by the unskillful performance of a surgical operation. Thus much concerning the great importance of the subject.

What qualifications the surgeon should possess.

The *phenomena* pertaining to traumatic hemorrhage also require brief mention in this place. These naturally divide themselves into two distinct classes; (1.) the *local*, or those which are developed at the seat of injury; and (2.) the *constitutional*, or those which are developed in the system at large.

Classification of the phenomena; (1.) the *local*; (2.) the *constitutional*.

With regard to the local phenomena, it should be stated that when the hemorrhage proceeds from a wounded *vein*, the effused blood has a dark color and usually flows in a steady stream. By these two facts or conditions we are always

Characteristics of venous hemorrhage.

able to recognize a venous hemorrhage with tolerable certainty; unless, perchance, the source of the bleeding is the distal orifice of a wounded artery, which I have seen in at least one notable instance.

It should be further stated in this connection that when the hemorrhage proceeds from a wounded *artery*, the blood usually has a bright red or scarlet color and flows in a jerking stream (*per saltum*). In such cases the jets by which the blood is discharged are synchronous with the pulsations of the heart. Between the jets, however, the flow does not entirely cease, but the stream becomes continuous, a fact which is the more readily observed if the wounded artery has a considerable size. The blood issues in jets, for the most part, from the proximal orifice in the wounded vessel only. The blood which escapes from the distal orifice is generally dark colored and flows continuously, thus resembling venous hemorrhage in those respects. But in some parts of the body the blood may issue in jets from the distal as well as from the proximal end of the divided artery, a circumstance which occurs in wounds of the palmar and the plantar arches, and sometimes when the arteries of the fore-arm are the seat of the lesion. As the hemorrhage progresses the jet becomes less strongly marked, because the volume of the circulating blood is diminished, and at the same time the heart's action grows weaker. The height and force of the jet are also modified by the size, shape, and direction of the wound of the parts external to the injured vessel. Thus, other things being equal, the jet is more strongly marked if the artery has been wounded directly, and with free incision, by a sabre-stroke, for example, than if it has been indirectly pierced by a stab with a narrow-bladed knife. Again, the jet varies according to the size of the injured vessel, and the extent of the aperture in it. This statement is so obviously true as not to require illustration.

Characteristics of arterial hemorrhage.

Phenomena of hemorrhage from the distal orifice.

With regard to the constitutional phenomena produced by hemorrhage, they are the following: The countenance becomes pale because the blood retires from the surface of the body, the lips acquire either a blanched or a livid hue, the pulse becomes diminished in volume, frequent, and feeble, the sufferer complains of a sensation of faintness and of want of air to breathe, the skin becomes wet with cold perspiration, the hearing becomes disturbed with strange noises in the ears, usually resembling either the hum of machinery or the sound of rushing waters; if now the hemorrhage continue, the sight becomes affected, and a mist or even a thick cloud appears before the suf-

Of the constitutional phenomena of hemorrhage.

ferer's eyes, the pulse becomes fluttering and finally almost imperceptible, the respiration sighing or even gasping, and consciousness disappears altogether; if now the hemorrhage cease, the system usually rallies, after a time the pulse can again be felt, the respiratory movements can again be perceived, vomiting not unfrequently occurs, and the consciousness is completely restored. But if, on the other hand, the bleeding continue, then the syncope becomes fatal, and the heart ceases forever to beat. Even when the consciousness has been restored and the system has partially rallied, in cases where the hemorrhage has been very profuse, the patient's safety is by no means yet assured; for it may happen that the sudden elevation of his head or even of a limb will induce a fatal syncope. Or, again, the disturbance in the condition of the great nervous centres from want of an adequate supply of blood may induce fatal *convulsive movements*. Or, still again, death may take place from *coma*, produced by extravasation of serum into the ventricles and into the meshes of the pia mater upon the surface of the brain, through the thin walls of the capillary blood-vessels, which appear to have become paralyzed, or at least to have lost their power of retaining the watery portion of the blood in its proper channels. Another untoward result which is not unfrequently produced by excessive loss of blood is the so called *hemorrhagic fever*, the leading characteristics of which are the features of irritative fever, that is, prostration with vascular excitement, conjoined with the symptoms of anæmia (Erichsen).

Profuse hemorrhage also produces a pinched appearance of the face and a shrunken condition of the whole body, since the size of the organism is absolutely diminished by the amount of the blood abstracted from it, and the loss in bulk at the same time falls heaviest or indeed almost entirely upon the soft parts lying upon the exterior of the body.

In cases of death by hemorrhage the *cadaver* presents a peculiarly blanched, yellowish-white, semi-transparent, waxen appearance, which cannot be produced by any other known cause.

The constitutional phenomena of hemorrhage are well marked.

It will thus be perceived that the *constitutional phenomena of hemorrhage when excessive* are very strongly marked, and of themselves sufficient to enable us to diagnosticate that condition with certainty, even in cases where the effusion takes place internally and not a drop of blood appears upon the exterior of the body.

The subject of traumatic hemorrhage as it was observed among our wounded during the War of the Rebellion, can be conveniently

considered under the following heads: (1.) *Primary hemorrhage*, that is, hemorrhage occurring during the primary period, or prior to the commencement of the inflammatory process (that is, the occurrence of inflammatory congestion) in the affected part; (2.) *Intermediary hemorrhage*, that is hemorrhage occurring during the intermediary period, or subsequent to the first twenty-four or thirty-six hours, and prior to the advent of suppuration; (3.) *Secondary hemorrhage*, that is, hemorrhage occurring during the secondary period, or after the establishment of suppuration; and (4.) *Parenchymatous hemorrhage*, or that form of bleeding in which the issue of the blood takes place not from any one vessel that can be named, but from the whole of the wounded or ulcerated surface. It therefore appears to be essentially capillary in character, and for the most part, to depend for its production upon causes which are widely different from those which occasion either of the other varieties of hemorrhage, as will be more fully shown in the sequel.

Classification of the traumatic bleedings.

The discussion of the subject of *primary hemorrhage* naturally takes precedence over that of any other form of traumatic bleeding. The special consideration of the *intermediary*, the *secondary*, and the *parenchymatous* forms of traumatic hemorrhage is therefore postponed at present, and will be taken up in the more advanced sections of this essay. Their importance is so great that it will not be profitable to attempt their discussion until we have obtained all the assistance which can be derived from the study of the primary variety of traumatic arterial bleeding, together with the various forms of injury to which the blood-vessels are subjected by accidents, by design, and by war.

Traumatic hemorrhage, and especially the *primary variety* of it, exhibits peculiarities in respect to its phenomena and consequences, in different cases, as already intimated; and they have been found to vary with the size, depth, and locality of the wounded artery, with the extent of the lesion in its walls, that is, according to whether it is completely or only partially divided, with the size and character of the breach in the soft parts exterior to the vessel, and with the nature of the wound of the artery itself, that is, according to whether it has been inflicted by a sharp cutting instrument which would produce an *incised wound*, or by a sharp pointed instrument like a dagger, or bayonet, which would occasion a *punctured wound*, or whether the vessel has been torn across by stretching, in the nature of a *lacerated wound*, such as is sometimes produced by machinery, or

The phenomena and consequences of traumatic hemorrhage how modified.

whether the coats of the vessel have been bruised, and thus sustained a *contused wound*, or finally whether the artery has been penetrated by a small-arms projectile which produces a lesion in the nature of both a contused and lacerated wound (*i. e.* a *gunshot wound*). In warfare, it is a matter of very great consequence to the surgeon to know the precise relationship which exists between gunshot wounds and hemorrhage, since those wounds constitute nearly all the traumatic lesions which are brought to his notice from battle. Bayonet and sabre wounds are of comparatively rare occurrence. Of 12,094 officers and men wounded in the British Army during the Crimean War, only 87 had sword and lance wounds, and 82 bayonet wounds (*vide Surg. Hist.* vol. ii. p. 257–9).

In warfare, gunshot wounds vastly predominate.

CHAPTER SECOND.

SOME GENERAL CONSIDERATIONS TOUCHING PRIMARY HEMORRHAGE FROM GUNSHOT WOUNDS, OR BATTLE-FIELD HEMORRHAGE.

Gunshot Wounds in general are less disposed to bleed than Incised Wounds, and the Reason. — When Limbs are torn off by Machinery, or by Railway Engines, or by Cannon-balls, the Hemorrhage does not of Necessity prove fatal. — Phenomena attending the Spontaneous Arrest of Hemorrhage in such Cases. — Wounded Part of the Vessel blended with the Disintegrated Tissues surrounding it. — Constriction of the Bleeding Orifice by Contraction of the Muscular Coat. — Occlusion of the Constricted Orifice by Coagulum. — Primary Hemorrhage from Gunshot Wounds seldom gives the Surgeon much Trouble. — The Personal Observations of the Author concerning Battle-field Hemorrhage. — At the Combat of March 29, 1865, on the "Quaker Road." — At the Battle of March 31, near the "White-oak Road." — At the Battle of "Ball's Bluff," Oct. 21, 1861, saw but One Patient suffering much from Loss of Blood. — But in this Case the Hemorrhage was venous, and mainly due to the Application of an Extemporaneous Tourniquet. — Much Damage may be done with Field Tourniquets in the Hands of Ignorant People. — The Author's Experience concerning Battle-field Hemorrhage at "Fair Oaks," May 31 and June 1, 1862. — Also at the Battles of "Peach-orchard," "Savage's Station," "Glendale," and "Malvern." The Large Arteries of the Extremities often escape Wounds by their Wonderful Resiliency. — Causes of said Resiliency enumerated. — Thus the Femoral, Carotid, and Brachial Arteries not unfrequently escape without any Serious Injury, when lying in the Track of Gunshot Projectiles. — The *Resiliency* of Certain Arteries does not afford the Principal Reason why Wounds of the Larger Arteries are but seldom seen by the Surgeon in Battle. The Real Reason is that the Subjects of such Wounds generally bleed to Death before they can be brought to a Surgeon. — Two Cases in Point related by Guthrie, viz., that of Sir Edward Packenham, and that of Col. Duckworth. — The Author's Experience on this Point. — He examined 43 Dead Bodies lying on the Field of Combat near Fort Steadman, in front of Petersburg, March 25, 1865. In a very Large Proportion of these Cases (considerably more than One Third) Death had been produced by Hemorrhage. — These Views are corroborated by a Case in which the Femoral Artery is known to have been divided by a Rifle-ball. — Also by a Case related by Surg. T. F. Azpell, U. S. Vols., in which the Axillary Artery was wounded by a Rifle-ball. — And also by a Case reported by Baron Larrey, in which the Carotid Artery was wounded by a Musket-ball at St. Jean d'Acre. — *Primary* Traumatic Hemorrhage is produced by Wounds of Blood-vessels and in no other Way. It may proceed from either an Artery or a Vein. — The Subject of Wounds of Blood-vessels must therefore be considered in Detail.

Gunshot wounds in general less disposed to bleed than incised.

GUNSHOT wounds of any part of the body do not in general bleed nearly so much as incised wounds of the same part. This difference is occasioned by the fact that the former are essentially contused and lacerated in their nature. It is well known that when blood-vessels are divided by either a contusing or a lacerating force, the disposition to hemorrhage is considerably diminished. Even when limbs are torn off by machinery, or crushed off by railway engines, or carried away by

cannon-balls, the loss of blood is not of necessity so great as to prove fatal. In such cases the bleeding, which is at first profuse, commonly ceases almost entirely on the approach of syncope. If we examine the bruised and torn stump of a limb which has just been severed by a cannon-ball, we find that the smaller vessels give issue to but little if any blood, because their divided ends are, for the most part, closed by being blended in the crushed mass of muscular and connective tissue in the first place, and by the natural contraction of their muscular coat in the second place. The large arteries in such cases may sometimes be seen hanging out of the ragged stumps and pulsating down to their ends, which, however, are closed more or less completely by the contraction of the muscular coat, and generally by the presence also of a plug of coagulated blood within the constricted orifice of the vessel. The completeness of the closure appears to vary, in some instances, with the length of time that has elapsed between the injury and the examination, being found to be more complete after a considerable than after a brief interval.

The personal observations of the author concerning battle-field hemorrhage.

The hemorrhage which accompanies wounds of the soft parts inflicted by rifle-balls is but seldom troublesome to the surgeon. On several occasions I have examined large numbers of wounded soldiers belonging to this category, soon after their wounds were inflicted, with a view to ascertain if any of them were suffering from hemorrhage, and I can now call to mind but very few cases in which the bleeding continued in a threatening manner at the time of the examination, or had even weakened the patient much by its profuseness. On the 29th of March, 1865, immediately after a sharp combat with the enemy on the "Quaker Road" had terminated, I examined about three hundred, all of whom were wounded by infantry firing, with reference to this point, and made the following note at the time: "A large proportion of the cases required capital operations; noticed on inspection that none of them had suffered much from hemorrhage." On the 31st of March, directly after the battle for the possession of the "White-oak Road," I examined about eight hundred wounded under similar circumstances, and with the same result.

At the battle of Ball's Bluff, October 21, 1861, I saw but one patient who was suffering much from loss of blood. He was pale and considerably weakened thereby. I found, on examination, that he had suffered a gunshot wound through the antero-inner part of the left arm, high up, and that, being alarmed by a smart flow

of blood which followed the infliction of his wound and did not immediately cease, he had, with the assistance of a comrade, applied an extemporaneous tourniquet to his arm above the wound, which consisted of a handkerchief rolled up and tied around the limb and then rendered sufficiently tense by twisting it with a piece of wood inserted underneath. The limb below the place of constriction was swollen and blue-colored, and dark-hued venous blood was seen issuing from the wound in a steady stream. On removing the extemporaneous tourniquet no arterial hemorrhage occurred, although the venous bleeding still continued. The radial pulse was as good in that limb as in the other one. It appears that the loss of blood had taken place mainly from wounded veins, and that he had promoted the hemorrhage by constricting his arm above the place of injury in the way already mentioned, whereby the return of the blood from the arm towards the heart through its natural channels was prevented, and it was thus induced to seek an outlet through the wound. His extemporaneous tourniquet had operated to promote the venous hemorrhage in precisely the same way that the leash applied to the arm does in venesection. Without such constriction it is not probable that his loss of blood would have amounted to much. I readily controlled the bleeding by making a moderate amount of pressure at the wound with a compress and bandage. The swollen condition of all the soft parts below the place of constriction, and the stagnation of blood in them, rendered it advisable to support the whole limb by a roller bandage carefully and evenly applied, from the fingers upwards, which was accordingly done.

Much damage may be done with field tourniquets in the hands of ignorant people.

This case shows that much mischief may be produced by the injudicious use of field tourniquets, and that these instruments should never be placed in the hands of ignorant persons.

At the battle of Fair Oaks, May 31 and June 1, 1862, among over five hundred wounded who came specially under my notice, I saw but one case of primary hemorrhage that proved troublesome. It occurred in the person of a non-commissioned officer who had sustained a compound comminuted fracture of the radius in its lower third, inflicted by a musket-ball, and appeared to depend upon some lesion of the radial artery. It was, however, finally controlled by pretty firm pressure applied over the wound, with a graduated compress and roller bandage, the hand, wrist, and lower part of the fore-arm being all included in the bandage; and did not recur.

At the battles of "Peach-orchard," "Savage's Station," "Glen-

dale," and "Malvern," I did not meet with a single case of primary hemorrhage which required a surgical operation, such as the application of a ligature, for its suppression.

The large arteries of the extremities are, to a considerable extent, protected against being wounded by rifle-balls, by the strength of the fibrous sheath which invests them, by the toughness and extensibility of their coats proper, and by the readiness with which they can slip aside from the track of the bullet by an instantaneous and momentary flattening, allowed by the fact that they are elastic tubes, and that they contain a liquid substance. By these means, doubtless, the large blood-vessels often escape from being lacerated by bullets; and in this way we can account for the fact that arteries such as the femoral, the carotid, and the brachial are found to be practically uninjured, although they may lay exactly in what appears to be the track of the bullet. The war has furnished numerous examples belonging to this class of gunshot injuries.

The large arteries of the extremities oftentimes escape being wounded by their wonderful resiliency.

Now, this immunity on the part of certain arteries from the wounds inflicted by small-arms, under favoring circumstances, does not in my opinion afford the principal reason why gunshot wounds of the larger arteries but seldom come under the surgeon's notice in battle. I am strongly impressed with the belief that, in such cases, death generally takes place speedily from hemorrhage, and that the unfortunate recipients of such wounds commonly die on the field of battle before they can be submitted to the surgeon's care. Guthrie states, that General Sir Edward Packenham received a wound directly through the common iliac artery, at New Orleans, which killed him on the spot, and that Colonel Duckworth, of the 48th Regiment, received a ball through the edge of his leather stock, at Albuhera, which divided the carotid artery, and killed him almost instantaneously. I am also convinced, from my own observations, that a large proportion of the persons killed in battle perish directly from loss of blood. On the 25th of March, 1865, I examined the bodies of forty-three soldiers as they lay dead where they had fallen, on the field of combat at Fort Steadman, in the lines before Petersburg.

Examined 43 dead bodies lying on the field of combat near Fort Steadman.

Of them 23 were wounded in the cranium,
15 were wounded in the thorax,
5 were wounded in the abdomen.

The blanched and exsanguinated appearance of the cadaver in every case wounded in the abdomen, de
that death had been produced by hemor-

rapidity with which that result had taken place implied that some large blood-vessel had been injured. In all but two or three of the cases wounded in the thorax, the body also presented a blanched and exsanguinated appearance, occasioned by hemorrhage. There was much blood in the clothing and on the ground where they had fallen, in most of the cases wounded in the trunk. This fact shows that the fatal hemorrhage generally took place externally. There were, however, some cases wherein death had been produced by internal hemorrhage. While the bodies of these were pallid and wax-like, there was but little blood in their clothing, and on the ground where they lay. All the wounds appeared to have been inflicted by cylindro-conoidal bullets.

Such cases as the following also tend to strengthen me in the conviction already expressed: An officer belonging to the Army of the Potomac, whose femoral artery was divided by a rifle-ball in the upper part of its course, the hemorrhage being very profuse, had the presence of mind to compress the vessel with his own fingers until he could be taken to a surgeon, who tied the vessel. He recovered. Surgeon T. F. Azpell, U. S. Vols., has related to me a case that came under his own observation, wherein the axillary artery was wounded near its origin by a rifle-ball; the hemorrhage, which was very abundant, was arrested immediately by digital pressure, and was restrained until a ligature could be applied to the subclavian artery; and the patient got well. Baron Larrey has reported the case of General Arrighi, Duke of Padua, who was wounded in the neck by a musket-ball at St. Jean d'Acre. The right carotid artery was wounded; and he must inevitably have died of hemorrhage if a soldier had not had the presence of mind to introduce his two forefingers into the wounds, until Larrey arrived and tied the vessel.

Primary hemorrhage of a traumatic character requires for its production a lesion, or solution in the continuity of the walls of a blood-vessel, occasioned directly by violence; and it is never developed in any other way. The injured vessel may be either an artery or a vein; but traumatic hemorrhage of such sort as to prove troublesome or difficult to manage, occurs much more frequently in connection with the former than with the latter. Primary traumatic hemorrhage.

It is therefore necessary to treat the subject of *wounds of the blood-vessels* in detail before proceeding to discuss the subject of primary hemorrhage, and the means by which its arrest may be effected, whether such means are afforded by nature or by art.

CHAPTER THIRD.

WOUNDS OF THE ARTERIES.

Wounds of Arteries much more important than Wounds of Veins in a Surgical Point of view. — Dr. Otis's remarks on Hemorrhage from Gunshot Wounds of Veins. — Classification of Arterial Wounds. — 1. *Punctured*; 2. *Contused*; 3. *Lacerated*; 4. *Gunshot*; 5. *Incised*. — Each of these Classes possesses Certain Features which characterize it. — Some of them enumerated.

Wounds of arteries more important than wounds of veins in a surgical point of view.

In considering the wounds of blood-vessels we shall treat first of *wounds of arteries*, because they are much more important in a surgical point of view than wounds of veins. Concerning the latter the following remark is made in Circular No. 6, by Dr. Otis, of the Surgeon General's Bureau: "No cases have been reported in which the bleeding could not be controlled by pressure."[1] This remark is made in connection with the subject of gunshot wounds of veins. It is also well known that, in civil practice, hemorrhage from wounded veins but seldom gives the surgeon much trouble.

Dr. Otis on hemorrhage from gunshot wounds of veins.

The various traumatic lesions to which the arteries are exposed may be classified under the following heads: —

1st. Punctured wounds,
2d. Contused wounds,
3d. Lacerated wounds,
4th. Gunshot wounds, and
5th. Incised wounds.

Each of these classes of arterial wounds, when the individual cases belonging to it are attentively considered, presents certain peculiarities in respect to phenomena and consequences which serve to characterize it. Thus we may here state that punctured wounds of arteries are as a class especially liable to produce traumatic aneurism; that lacerated wounds of arteries are upon the whole less inclined to bleed than the other varieties; that contused wounds of arteries are apt to be followed by secondary hemorrhage from ulceration of the bruised coats of the injured vessel; that gunshot wounds of arteries are characterized by the features be-

[1] Page 39.

longing to the last two classes; and that incised wounds of arteries are especially prone to cause death from primary hemorrhage.

We shall follow the order above mentioned in considering this branch of our subject.

1. PUNCTURED WOUNDS OF ARTERIES.

What Maissonneuve has shown concerning the Consequences of Minute Punctured Wounds of Arteries. — Guthrie mentions Two Cases in which Tenaculum Wounds of the Femoral Artery were followed by Ulceration and Secondary Hemorrhage. — Guthrie thought that a Longitudinal Fissure of One or Two Lines did no Harm. — But Deschamp's Case shows that he was mistaken. — Summary of this Case. — Brachial Artery punctured with the Point of a Knife. — Description of the Phenomena that ensued. — Traumatic Aneurism produced with Recurring Hemorrhages and Death from Exhaustion. — Various Instruments enumerated with which Arteries have been punctured. — This Lesion may be produced by a Sharp Fragment of Bone in Cases of Simple Fracture. — Also by the Sharp End of a Sequestrum. — But in Warfare it is occasioned by Bayonet, Sword, and Lance Wounds. — Only One Instance recorded where an Artery was wounded by these Weapons in the British Army during the Crimean War. — A Case of Bayonet Wound of the Right Buttock contributed by Dr. H. M. Lyman. — The Weapon penetrated the Pelvis through the Ischiatic Notch, and punctured the Anterior Trunk of the Internal Iliac Artery; a Traumatic Aneurism formed; the Primitive Iliac was tied; Death Five Days afterwards from Gangrene of the Sac. — Of the Symptoms produced by Punctured Wounds of Arteries. — The Consequences of these Wounds are generally troublesome and dangerous. — They are enumerated. — Traumatic Aneurism frequently a Consequence. — Arterio-venous Aneurism sometimes follows a Punctured Wound. — Punctured Wounds of Arteries when minute occasionally give rise to Ulceration and Secondary Hemorrhage. — An Illustrative Specimen preserved in our Army Medical Museum referred to. — Treatment. — The Old Operation to be preferred in all Cases where its Performance is practicable. — Reasons why a Distal Ligature should be applied. — Treatment of Punctured Wounds of Arteries, when produced by Simple Fracture. — The Old Surgeons resorted to Amputation. — J. L. Petit cut down upon and tied the Artery at the Place of Injury. — Dupuytren tied the Main Artery at Some Distance from the Place of Injury. — Objections to each of these Plans of Treatment in Cases of Simple Fracture considered. — The Principles upon which Punctured Wounds of Arteries should be treated in Cases of Fracture stated.

Maissonneuve has shown that an artery may be pierced by a delicate instrument, such as a fine needle, without the production of hemorrhage, or any other unfavorable result. But if the vessel be pierced by a larger instrument, such as a tenaculum, disastrous consequences may follow. Thus, Mr. Guthrie saw two cases in which the femoral artery was wounded by a tenaculum, and ulceration, followed by hemorrhage, took place in both, requiring the application of a ligature.[1] Mr. Guthrie also thought that a longitudinal fissure in the coats of an artery, of from one to two lines in extent, was not attended by bad consequences. But the case reported by Deschamps renders it probable that he was mistaken. In that case the brachial artery in the upper part of its course was penetrated by the point of a knife. The wounded man walked a little way, but being weakened by the loss of a large quantity of blood, he fell to the ground in a state of in-

Puncture of brachial artery.

[1] Vide *Diseases and Injuries of Arteries*, p. 212, London, 1830.

sensibility. On the eighth day copious hemorrhage again occurred. On the ninth and tenth days small hemorrhages took place. On the morning of the eleventh day it recurred to an alarming degree, the bed being soaked through with black and fetid blood. At noon the bleeding again returned with violence. The patient died, and on opening the body, Deschamps found that *the brachial artery had been wounded in a longitudinal direction*, at its external and posterior aspect, *to the extent of two lines*, opposite the inferior border of the tendon of the pectoralis major muscle, and above the origin of the superior profunda artery.[1] In this case, a traumatic aneurism was produced, for the relief of which several operative procedures were employed in vain, and the patient lost so much blood that, in the end, his life was destroyed. Such were the consequences of a punctured wound of the brachial artery, having a length of only two lines. If the aperture has a greater size than that, the risk of a bad result is likely to be correspondingly increased, unless it is averted by the surgeon's skill.

Causes. — Punctured wounds of arteries may be inflicted with the point of a sharp pair of scissors, as happened in a case reported by Deschamps, in which the femoral artery was wounded by that means; with the blade of a penknife, whereof there are several examples on record; with a lancet in the careless performance of the operation of venesection at the bend of the elbow, which has often happened both in ancient and in modern times; and, finally, with a pocket-knife, dagger, sword-cane, or any other narrow-bladed instrument. Punctured wounds of arteries may also occur in connection with fracture of the long bones of the extremities, by means of a sharp splinter or fragment of bone being driven into such a vessel. This accident is believed to occur more frequently in the leg, than in any other part of the body, as seems to have happened in some of Dupuytren's published cases. An artery may also be punctured with the sharp end of a fragment of necrosed bone, as happened some years ago in this city,[2] in a case in which the popliteal artery was pierced by the point of a femoral sequestrum, and with a fatal result. But in warfare punctured wounds of arteries are inflicted with the bayonet and the sharp points of swords and lances. Concerning this form of injury occurring among the wounded of the British army in the Crimean War, it is said: "The only recorded instance of an artery having been wounded by sword or bayonet thrust was in the 18th Regiment, in

Arteries punctured by bone.

By the bayonet, sword, or lance.

Only one instance recorded

[1] Vide *Observations on Aneurism*, Sydenham Soc. ed. p. 406–409, London, 1844.

[2] New York.

the person of a color-sergeant, who was accidentally struck in the leg, by the bayonet of one of the men, and the posterior tibial artery wounded. The case, however, presented no peculiarities. A double ligature was applied, and recovery took place."[1]

where an artery was wounded by these weapons in the British army during the Crimean War.

The following case, which occurred in the person of a soldier during the war of the rebellion, affords a very interesting example of punctured wound of the internal iliac artery, or rather of its anterior trunk, on the right side, inflicted with a bayonet. It was followed by a false, consecutive, or traumatic aneurism, which ultimately attained a great size. Nearly seven months subsequent to the infliction of the injury, death by hemorrhage being imminent, the common iliac artery was tied. Subsequently, the wound of operation did well, but the aneurismal sac became gangrenous, and the patient died with symptoms of rapid systemic poisoning, four days after the operation. The report of this case was contributed by H. M. Lyman, M. D., late Acting Assistant Surgeon U. S. Army.

Dr. Lyman's case.

Case I. *Bayonet Wound of Right Buttock, penetrating Pelvis through Ischiatic Notch; Traumatic Aneurism of Anterior Trunk of Internal Iliac Artery from Punctured Wound of it; Ligature of Primitive Iliac; Death Five Days afterwards from Gangrene of the Sac; Autopsy.* — August Zapka, aged 25, Company H, 35th Wisconsin Volunteer Infantry. Was wounded while in camp near Milwaukie, Wis., March 18, 1864. Was treated in the camp hospital. Bled about a pint at date of injury. Urine drawn by catheter for four days, and contained much blood. Then occurred great swelling of abdomen and right buttock. After two months this decreased; he began to walk, and, July 12, he was sent to his regiment at White River, Arkansas. There, after two days' duty, the swelling returned. He was sent to hospital at New Orleans. Was treated with applications to relieve pain which he described as "hammering pain." Said he saw pulsations in the tumor. He was furloughed, placed on a hospital boat, and sent North. A surgeon on the boat opened the tumor, and, blood escaping, the opening was closed again. Oozing of blood constantly occurred; and arriving in Chicago in a weakened condition, he was admitted to the Marine Hospital, September 30, 1864. October 5 and 6, alarming hemorrhage occurred from the wound. A hard, tense, shining tumor occupied the right buttock from crest of ilium to fold of nates, and from the sacrum to anterior superior spinous process of ilium. The cicatrix of the original wound was visible near the centre of the tumor, and beside it was the open wound inflicted by the surgeon of the hospital boat, filled with protruding clots,

[1] Vide *Surgical History of British Army in Crimean War*, vol. ii. p. 366.

and (Oct. 7) giving escape to arterial blood. Much throbbing pain and numbness of the limb, with difficulty in voiding urine. Bruit audible, but no pulsation can be felt. Tumor very hot, great constitutional irritation. On consultation it was decided to deligate the primitive iliac.

Operation. — Chloroform having been administered, the operation was performed by Dr. Isham, Acting Assistant Surgeon U. S. Army.

Progress. — Oct. 7, 1864, seven o'clock P. M. Patient comfortable. Bottles of warm water and cotton to the limb. Morph. sulph. $\frac{1}{4}$ grain. Oyster broth. Slept well all night; limb warm. Oct. 8, seven o'clock A. M. Pulse 130. Give four drops tr. verat. virid. Eight o'clock P. M. Pulse 80. Has passed a comfortable day. Oct. 9, seven o'clock A. M. Rested well over night. Pulse 100. Wound appears healthy. Discharging pus. Eight o'clock P. M. Had a comfortable day, but now complains of pain in the bowels. Relieved by small dose of morphine. Oysters and beef tea. Oct. 10. Rested well; looks well. A sanious discharge from old wound of sac, which was injected with a disinfecting solution of potass. permangan. Oct. 11, eight o'clock A. M. Pulse 86. All symptoms favorable, except the offensive discharge from the sac. Oct. 12. Patient died at ten o'clock A. M., with symptoms of rapid systemic poisoning or septæmia.

Post-mortem Examination — Showed healthy condition of the artery; well organized clot extending from the ligature to the aorta. No peritonitis. The sac of the aneurism (corresponding to the description already given) was gangrenous. The wound of the artery proved to be of the anterior trunk of the internal iliac within the sacro-ischiatic notch.

Considering the size and importance of the artery which was wounded in this case, it appears to me surprising that the patient recovered from the effects of the original injury to such an extent as to justify the sending of him to duty with his regiment, about four months after the wound was inflicted. But it does not seem at all surprising that the swelling and other symptoms of traumatic aneurism reappeared after the performance of military duty for only two days.

Symptoms produced by punctured wounds of arteries.

The *symptoms* presented in cases of punctured wounds of arteries are those which belong to punctured wounds in general, that are inflicted with the same kind of a puncturing instrument, whether it be bayonet, or sword, or dagger, upon the same region of the body, with the addition of arterial hemorrhage from the wound. If the orifice in the integuments be closed and kept closed, then the blood is extravasated from the wounded vessel into the neighboring connective tissue, and a pulsating tumor called a traumatic aneurism is produced.[1]

[1] Vide Chapter on Traumatic Aneurism.

The *consequences* of punctured wounds of arteries are generally troublesome and dangerous, unless the bleeding vessel is promptly secured by the surgeon's art. Unless that is done, death is liable to be produced by hemorrhage. The first bleeding may prove fatal, or in case it is arrested by temporizing expedients it may recur again and again, until it wears out the patient and kills him by exhaustion; or the external wound remaining closed and the blood still continuing to escape from the vessel into the connective tissue, it may burrow widely and produce death by compressing some important organ, or the tissues thus infiltrated with extravasated blood may inflame and suppurate through a great space, and life be ultimately destroyed by septæmia or exhausting suppuration. Indeed, the best result which is likely to occur to a patient having a punctured wound of an artery of considerable size, when treated with temporizing expedients, is the occurrence of traumatic aneurism of a circumscribed character, which is certainly bad enough at best.

Traumatic aneurism.

Punctured wounds of arteries not unfrequently lead to the formation of traumatic aneurisms. This form of injury is more apt to produce such a result than any other traumatic lesion to which the blood-vessels are subjected. Especially does this obtain when the injury is inflicted upon an artery in the continuity of a limb.

Arterio-venous aneurism.

Punctured wounds of arteries are also sometimes followed by arterio-venous aneurism, a vein having been wounded at the same time as the artery. This accident occurs most frequently at the bend of the elbow from mistakes in blood-letting, but it has also been known to happen in the thigh and in the neck from accidental injury.

Ulceration and secondary hemorrhage.

Punctured wounds of arteries, when they are minute, and have not bled during the primary period, occasionally give rise to secondary hemorrhage from ulceration of the vessel occurring at the place of injury, as happened in two instances mentioned by Guthrie (and cited by us on a previous page), in which the femoral artery was wounded with a tenaculum. There is also a specimen in our Army Medical Museum which illustrates a similar occurrence. It consists of a popliteal artery from which secondary hemorrhage took place eleven days after it was punctured by a spicula of bone. The femur was obliquely fractured by a pistol-ball, in its lower third, with slight comminution. The artery did not bleed until its coats sloughed at the place of puncture. The hemorrhage was then arrested by tying

the femoral, but traumatic gangrene of the limb supervened, and death occurred three days after the operation.[1]

The *plan of treatment*, which is most likely to avert the disastrous consequences above-mentioned, consists in promptly exposing the wounded vessel at the place of injury by suitable incisions, and applying two ligatures to it, one on each side of the bleeding orifice, as recommended by the ancient surgeons. When it is not practicable to perform this operation, because the point of vascular injury is situated in an inaccessible part of the body, as it was in the case just related,[2] it is generally advisable to occlude the wounded artery or the main trunk from which it springs, with a ligature applied at some distance from the wound, but as near to it as practicable. But this expedient should not be resorted to unless the performance of the old operation is entirely out of the question. A ligature should be applied on the distal as well as the proximal side of the orifice, because, unless this is done, the hemorrhage is liable to recur as soon as the parts below the wound become well supplied with blood through the collateral channels. Then the blood flows backwards in the wounded vessel and escapes through the breach in its walls, unless the canal has previously been occluded by the resources of nature or surgical art.

When the principal artery of a limb has been pierced by the sharp end of a fracture splinter without corresponding wound of the integuments, as, for example, in a case of simple fracture of the leg, and blood is extravasated into the connective tissue in such quantity, or to such extent, as to make an operation necessary, three different surgical procedures have been employed. The old surgeons amputated the injured member. J. L. Petit cut down upon the wounded vessel, and tied it on each side of the rent in its coats. This innovation was attended with success. But Dupuytren tied the femoral artery as recommended by John Hunter for the cure of spontaneous aneurism of the ham, and his proceeding also was successful. Now, there are some serious objections which may be urged against each of these plans of treatment. Thus, the principal objection to amputation as a remedial measure in cases of simple fracture with wound of an important artery produced internally by a sharp spicula of bone, is that its performance involves a severe mutilation, and imposes upon the patient the serious loss and perils pertaining to that operation.

The main objection to employing the method of J. L. Petit in such cases is, that his proceeding converts a simple into a com-

[1] Vide *Catalogue*. Specimens 4084, 4085. [2] Case No. 1.

pound fracture. The objections to Dupuytren's procedure are two in number; first, the ligation of the main trunk on the plan of Hunter may fail to permanently restrain the bleeding, and second, such operation is liable to induce traumatic gangrene, especially when the lower extremity contains the fractured part. Bearing in mind these objections to the several operative procedures which have been employed for the arrest of bleeding from arteries when wounded by fracture splinters, we should consider well the special features or complications of each case as they present themselves when our services are required, and should select that plan of operating which seems most likely to lead to a successful issue. If, for example, the bone is much comminuted, the subcutaneous tissues of the limb besides the artery much bruised and torn, the swelling great, and the injury situated in the lower extremity, we would prefer amputation to either of the other operative procedures; but if the swelling and local disintegration of tissue are small or moderate, or the injury is situated in the upper extremity, we would perform the operation recommended by Dupuytren in preference to amputation. When, however, the fracture itself is compound, we generally prefer to tie the bleeding vessel in the wound with both proximal and distal ligature, unless the destruction of bones and nerves and muscles and integuments is so extensive as to demand amputation.

Principles of treatment in cases of fracture.

This subject is very important, and will be further considered in connection with lacerated wounds of arteries, and the discussion of traumatic aneurism.

2. CONTUSED WOUNDS OF ARTERIES.

This Lesion occurs much more frequently in Military than in Civil Practice, and is generally produced by Small-arms Projectiles. — Consequences of Contusion of the Arterial Tunics when severe. — 1. *Inflammation*, as happened in a Case reported by Guthrie. — 2. *Sloughing* of the Bruised Tissue, and Secondary Hemorrhage. — A Case in Point. — Gunshot Wound of Lower Part of Leg; the Bullet grazed the Posterior Tibial Artery; Secondary Hemorrhage on the Eighth Day from Ulceration of the Bruised Coats of that Vessel; Amputation; Death Thirteen Days afterwards from Pyæmia. — Primary Amputation ought to have been performed in this Case. — Reasons why Secondary Amputation was not resorted to at an Earlier Period. — Another Case belonging to the same Category. — Secondary Hemorrhage from the Posterior Tibial Artery, when it had been bruised Sixteen Days before by a Minie Ball in Connection with Gunshot Fracture of the Ankle-joint; Amputation; Death Nine Days afterwards from Exhaustion. — This Patient probably died of Osteo-myelitis. — Another form of Gunshot Contusion of Blood-vessels. — It occurs when Limbs are crushed but not torn off by spent Cannon-balls, etc. — Specimen from Railroad Case referred to. — It is preserved in the Army Medical Museum. — Another Illustrative Case. — Gunshot Wound of Left Arm with Contusion of Brachial Artery and Median Nerve; Secondary Hemorrhage One Month afterwards, which was arrested by tying the Vessel; Recovery. — Constriction and Occlusion of Arteries as Results of Bruises of their Walls. — A Case in Point. — Femoral Artery diminished in Calibre to one half its Natural Size in Consequence of a Gunshot Projectile striking against its

Sheath; Gangrene; Amputation; Death on the Thirty-first Day afterwards from Pyæmia. — Of Gangrene as a Result of Arterial Stricture. — Some of the Vasa Vasorum were lacerated by the Stroke of the Projectile in the Case just related, and Blood was extravasated between the Vessel and its Sheath, so as to compress the Former. — An Artery may be constricted or occluded in Consequence of Contusion of its Walls. — 1. By Extravasation of Blood within the Sheath; and 2. By Inflammatory Swelling. — A Specimen belonging to the Army Medical Museum shows that a Bruised Artery may be occluded by the Inflammatory Process. — In Guthrie's Case, already mentioned, the Occlusion was largely due to the Inflammatory Process. — An Interesting Case belonging to the same Category is related in the "Surgical History of the British Army in the Crimean War." — Four Cases have thus been mentioned in which the Main Artery of the Lower Extremity was constricted or occluded in Consequence of Contusion. — In all of them Consecutive Gangrene occurred. — But Gunshot Contusion of the Femoral Artery does not always induce Traumatic Gangrene, when the Vessel is occluded. — An Illustrative Case. — Treatment. — Secondary Hemorrhage necessitates either Ligation in the Wound, or Amputation. — Gangrene generally requires Amputation.

Generally produced by small-arms projectiles.

This variety of arterial injury is seldom met with except in military practice, and generally occurs in connection with wounds inflicted with small-arms. For example, a musket, rifle, carbine, or pistol-ball while passing through a limb may chance to strike its principal blood-vessel. Now, the artery by means of its resiliency may readily spring to one side and allow the passage of the projectile without sustaining a solution of its own continuity, and this is more likely to occur if the velocity of the projectile be considerably diminished at the moment of impingement against the vessel. But, in such cases, it happens not unfrequently, that the walls of the artery, although not penetrated nor divided by the projectile, are more or less considerably bruised by it. If the contusion of the artery chances to be severe,

Consequences of contusion of the arterial tunics, when severe.

one of two occurrences will be likely to follow, namely, either an inflammation of the artery at the place of injury will be produced, to such extent, and of such a character, as to speedily obliterate the calibre of the vessel, which indeed happened in a case reported by Guthrie,[1] or, on the other hand, the bruised portion of the arterial tunics will become separated from the sound portion by the process of ulceration, after the lapse of a number of days, and secondary hemorrhage will then take place. This form of hemorrhage, *i. e.*, bleeding produced by contusion of an artery, usually occurs from the eighth to the twentieth day.

The following case affords a good example of it. The posterior tibial artery, near the ankle, was the vessel involved. Several very minute fragments of bone also were driven into the walls of the vessel by the bullet, the velocity of which appears to have been considerably retarded at the time it reached the artery by its pre-

[1] Vide *Diseases and Injuries of Arteries*, London, 1830, p. 242.

vious passage through the lower end of the tibia, and perhaps by other causes.

Case II. *Secondary Hemorrhage from Posterior Tibial Artery on the Eighth Day after the Infliction of a Gunshot Wound; the Bullet grazed the Vessel and drove some very Small Fragments of Bone into it from the Tibia; Amputation; Death Thirteen Days afterwards from Pyæmia.* — Private John Heakim, Company D, 6th U. S. Cavalry, aged 24 years, was admitted to the Stanton U. S. Army General Hospital, June 4, 1864, from the field, on account of a gunshot wound of his right leg at the ankle, inflicted by a minie ball, May 31st, four days previously, near Old Church, Va. The projectile entered in front, somewhat to the outer side, and, passing backwards and inwards, escaped behind the lower end of the tibia, going in close proximity to the posterior tibial artery in that locality. The ankle-joint was also involved in the wound. It was resolved to continue the effort to save the limb which had already been commenced.

On the night of June 7, arterial hemorrhage from the wound supervened, and he lost about a pint of florid-colored blood before it was arrested.

The ankle was much inflamed, being swelled, hot, red, and tender. The swelling also extended to the lower half or three fourths of the leg.

There remaining now no hope of saving the leg, it was amputated by the author on the morning of the 8th, at the place of election, by the flap-method. The tibia was divided after the procedure of Sanson. Sulphuric ether was employed as the anæsthetic. The loss of blood occasioned by the operation was but trifling. The shock was but little. It quickly passed away, and was followed by moderate reaction.

When the operation was performed, the patient's general condition was favorable. He had no constitutional disturbance worth mentioning.

The autopsy of the amputated member showed the lower end of the tibia to be badly comminuted into the ankle-joint, which was filled with purulent matter. The astragalus also had been injured by the projectile. *The posterior tibial artery had been grazed by it, and several very small fragments of bone had been driven into the walls of that vessel by it. The hemorrhage occurred on the separation of the bruised tissue belonging to the coats of the artery, and the detachment of the minute fragments of bone from the walls of the vessel by the ulcerative process.*

The patient did well for a number of days, but ultimately died of pyæmia thirteen days after the operation.

Comments. — In this case *primary amputation* of the injured member ought to have been performed. This is clearly shown by the clinical history of the patient, and by the badly comminuted condition of the lower end of the tibia, involving the ankle-joint in the injury, which was found on making

Primary amputation ought to have been performed.

an examination of the part. From the moment the wound was inflicted, there was no ground for entertaining a reasonable hope of saving this limb.

The question naturally arises why *secondary amputation* was not performed on the arrival of the patient at a general hospital, to which the reply is, that, at the time of his admission, secondary amputation proved fatal in almost every instance where it was employed for the removal of a leg, thigh, arm, or fore-arm. Indeed, until the occurrence of the secondary hemorrhage, it was believed that the patient would survive longer without the performance of that operation than with it. We therefore felt it to be our duty to continue the attempt to save the limb until the bleeding made it necessary to interfere with an operative procedure.

The next case affords another example of a contused wound of the posterior tibial artery, and presents many points of resemblance to the one last narrated.

Case III. *Secondary Hemorrhage from Posterior Tibial Artery that had been bruised by a Minie Ball Sixteen Days previously, in Connection with a Gunshot Fracture of the Ankle-joint; Amputation; Death Nine Days afterwards from Exhaustion.* — Private Thomas Acker, Company A, 155th N. Y. Volunteers, aged 40 years, admitted to Stanton U. S. Army General Hospital, June 12, 1864, from the field, had received a gunshot wound with comminuted fracture of the right ankle-joint, in the action at Cold Harbor, Va., May 28, 1864. A leaden bullet passed transversely through the joint from within outwards, and, to some extent, involved the track of the posterior tibial artery.

At time of admission the wounded ankle was moderately swelled and inflamed. The patient's general condition was favorable.

On the next day, June 13, while Dr. Osborne, the attending surgeon, was making his morning visit to the ward, this patient was attacked by secondary bleeding from the wound, arterial in character, and he lost about three ounces of blood before the hemorrhage was arrested. The writer saw the case immediately afterwards. There was no pulsation in the posterior tibial artery at the ankle, while that of the anterior tibial could be distinctly felt. It was evident that the hemorrhage proceeded from the posterior tibial artery.

Considering that the bleeding was complicated with gunshot fracture of the ankle-joint, it was deemed advisable to amputate the leg, which was done without delay, the patient being under the influence of sulphuric ether. The operation was performed by the author in the lower part of the middle third of the leg, by the method of anterior and posterior skin-flaps, semi-elliptical in shape, and equal in length. All the cutting was done with a scalpel. But little blood was shed by the operation. But little or no "shock" was produced. Did not employ any

sutures in dressing the stump; closed it with strips of isinglass plaster alone.

Examination of the amputated limb showed that the lower end of the tibia, the astragalus, and the os calcis had severally sustained comminuted fracture; *that the posterior tibial artery had been grazed and contused by the bullet, and that it had subsequently been opened by exulceration of the bruised portion of its walls.*

This patient died nine days after the operation, apparently from exhaustion. I believe, however, that he had *osteo-myelitis*, and that the fatal result should be attributed to the occurrence of that disease.

Another form of gunshot contusion of blood-vessels, a form which differs considerably from the foregoing examples of that lesion, in respect to the appearance presented by the wounded parts, is mentioned in the "Surgical History of the British Army in the Crimean War," and in the following words: "When a limb is crushed by shot or shell, but not carried away, the coats of the artery are often found to remain continuous, and primary hemorrhage to be thus rendered impossible, although their vitality may have been totally destroyed." [1]

Another form of gunshot contusion of blood vessels.

I have never seen an instance of this form of vascular contusion, but yet I can readily believe that it sometimes occurs in connection with those terrible bruises of the extremities which are not unfrequently produced by cannon-balls or fragments of shell, without breach of the integuments. In such cases, the continuity of the blood-vessels is preserved until sloughing occurs, for the same reason that the integuments remain unbroken till the same period arrives.

The Army Medical Museum also contains a specimen which serves to illustrate an important class of injuries occurring not unfrequently in civil life, and bearing considerable resemblance to those vast breaches of the deep-seated tissues which are sometimes produced by cannon-balls, or bombs, or rifled shells, as mentioned above. This specimen was obtained from a railroad case, and is "a wet preparation of the axillary artery, curiously obliterated at the passage of the pectoralis minor. The attached subclavian vein is ruptured. In this subject the humerus and clavicle were comminuted, and the soft parts between the shoulder-joint and the sternum pulpified by being crushed between two cars. No pulsation could be felt at the wrist, and sphacelus from the shoulder to the arm occurred."

Railway injury.

The patient was admitted to hospital, July 20, and died July 23, 1863. No operation was performed.[2]

[1] *Vol. ii.*, p. 340.

[2] Vide *Catalogue*, p. 468, specimen 1640.

When limbs are crushed off from being run over by railroad engines, the blood-vessels and parts surrounding them, at the place of injury, are generally found pulpified as in the foregoing specimen; and, as a rule, but little bleeding occurs.

In the following case the *brachial artery* appears to have been contused in the upper part of its course, from being struck by a cylindro-conoidal bullet. The humerus was not injured, and the accident was successfully treated without amputation.

Case IV. *Gunshot Wound of Left Arm, with probable Contusion of Brachial Artery and Median Nerve; Secondary Hemorrhage One Month afterwards, which was arrested by Ligature; Recovery.* — Private A. E. Williams, 37th Company, 2d Battalion Veteran Reserve Corps, aged 28, states that he was wounded in the battle of Gettysburg, July 2, 1863, by a minie ball, which passed through the inner side of the left arm, across the course of the brachial artery, about three inches below the fold of his armpit, and then passing onwards made a seton wound in the walls of his thorax on the left side. The bone was not injured.

Says he was taken to Chestnut Hill Hospital in Philadelphia. Says the track of the bullet in his arm sloughed so as to connect together both the orifices of entrance and exit. But on the night of August 3, a more serious difficulty occurred, for a slough of the brachial artery separated, and he came near dying from hemorrhage. The bleeding was, however, controlled by a proximal ligature applied in the wound. Afterwards the wound did well, he says, and healed in a short time.

October 16, 1864. — Present condition. The left arm is much smaller than the sound one. It is atrophied. Its temperature is, generally, lower than that of the sound one. It is blue-colored, as compared with the other arm, fore-arm, and hand, from stagnation of the circulating blood (venous congestion). He can execute a considerable variety of movements with the injured limb, such as taking off his cap, etc.; but the range of motion is a good deal restricted. He complains much of want of power in the limb. He says he cannot lift any weight with it worth speaking of. The index finger sticks straight out, *i. e.*, it is extended, and he cannot flex it at all. He can flex the little finger completely, the ring finger almost completely, and he can flex the middle finger about half way. He has no difficulty in extending these fingers.

There is a large cicatrix on the inner side of the arm, two or three inches below the fold of the armpit. There are also two scars upon the left side of the chest which mark the places of entrance and exit of the bullet. He says he is not any better in respect to capacity of motion than he was last spring.

There is a radial pulse in the injured limb, but it is quite small in volume, and quite feeble in point of strength. He has some malarial difficulties (*e. g.*, chills and fever), but in other respects his health is good

The bullet probably contused the median nerve, and, perhaps, also divided some of the filaments belonging to it.

The bullet also probably contused the brachial artery, and in this way laid the foundation for the subsequent sloughing of that artery, and the consequent hemorrhage.

He was discharged from the service, October 17, 1864, on surgeon's certificate of disability, at Stanton U. S. Army General Hospital.

The history of this case serves to illustrate the consequences of gunshot contusion of important blood-vessels and nerves, and the good results of timely deligation of the bleeding vessel, when the condition of the limb in other respects admits the performance of that operation.

Constriction and occlusion of arteries as results of bruises of their walls.

Again, in cases where the bruise is not severe enough to cause the coats of the artery to slough, and thus produce secondary hemorrhage, it may still excite a morbid action in the arterial tunics of such a nature as to result either in a considerable constriction, or even a complete occlusion of the vessel at the place of injury, and thus produce disastrous consequences. The following example is in point: —

Case V. *Femoral Artery diminished in Calibre to One Half its Natural Size in Consequence of a Gunshot Projectile striking against its Sheath; Gangrene; Amputation; Death on the Thirty-first Day after the Operation, from Pyæmia;* reported by Assistant Surgeon W. Teal, 88th Indiana Volunteers. — Henry Knoble, private, Company D, 149th N. Y. Volunteers, wounded at battle of Ringgold, Ga., November 27, 1863, in upper part of both thighs and back of neck. A minie ball entered the left thigh, on its antero-outer surface, six inches below the anterior superior spinous process of the ilium, dipped beneath the integuments and deep fascia, and emerged on its inner surface, four inches below the pubes. The same ball also wounded the right thigh, after passing through the left.

Saw case for first time, December 11; removed a minie ball from wound of neck; on examination found the *left foot in a state of humid gangrene*, with a line of demarcation encircling the ankle at the malleoli.

On inquiry learned that this soldier was admitted to hospital on the morning of November 28, the next day after injury; that his foot was cold and insensible at the time; that he was hungry and cold when admitted; that he had suffered considerably from exposure to cold on the battle-ground and during transportation to hospital; that he had diarrhœa when the wounds were inflicted, and that he had suffered from said disease more or less since entering the hospital. Opiates were exhibited in order to control his bowels, and tonics and stimulants to invigorate his system.

December 14. — Amputated his leg at the junction of its middle and lower thirds; artery controlled by thumb alone; very little hemorrhage; parts at place of section flabby.

Continued the plan of treatment (general) above-mentioned; applied to the stump freely alcohol of good strength, from the first. But little inflammation occurred, and but feeble efforts at repair were made. The granulations were sparse and flaccid throughout.

Death occurred, January 14, 1864, on the forty-eighth day after injury, and the thirty-first after amputation, from pyæmia.

Autopsy. — The bones of the stump protruded, and the flaps were lined with an ashy-gray slough. The orifices of the thigh wound were closed, but the track of the ball was occupied by an abscess containing thin fetid pus. The ball appeared to have passed behind the femoral artery, impinging against the sheath, however, in its course. At this point the walls of the artery were much thickened, and its calibre diminished one half. The sheath contained a firm coagulum about one inch long. The specimen was sent to the Army Medical Museum, and is thus described in the Catalogue: "A wet preparation of the upper portion of the left femoral artery, with the walls much thickened by a coagulum in the sheath, following impingement of a ball, which induced diminution of calibre."[1]

Gangrene as a result of arterial stricture.

Concerning the cause of the gangrene the reporter remarks: "The gangrene in this case was clearly due to the diminution of the calibre of the artery, and to the cold and exposure to which the man was subjected. Neither cause of itself appears to have been sufficient to produce the result."

Comments. — The wounds which this soldier sustained, although several in number, would not, in all probability, have caused any consequences of a serious nature if the projectile had left the femoral vessels unscathed. So far as his injuries were concerned, it appears to have been the lesion of the femoral artery that alone produced the mischief. This lesion, therefore, possesses a very important character. It also presents some remarkable features. The stroke of the projectile, although it was not sufficiently powerful to lacerate the sheath, still proved strong enough to bruise it severely,

Vasa vasorum lacerated.

and to rupture some of the *vasa vasorum*, and thus give rise to extravasation of blood within the sheath, in the loose connective tissue which lies between that structure and the artery. Besides this interstitial hemorrhage, it occasioned more or less inflammatory swelling of the bruised sheath and injured coats of the vessel at a somewhat later period. Now the combined effect of these two factors operating within the unyielding sheath of the

[1] Vide *Catalogue*, p. 456, specimen 2114.

vessel must be to diminish its bore in a corresponding ratio; and thus in the case just related, they sufficed to diminish the calibre of the artery to one half its natural size, as was clearly shown at the autopsy.

It therefore appears to be satisfactorily established, that when contusion of an artery results in the constriction or occlusion of its canal, two distinct morbid events or conditions may be concerned in the production of the stricture. 1. Extravasation of blood within the sheath from rupture of the nutrient vessels of the artery, and 2. Inflammatory swelling of the bruised laminæ of the sheath and tunics of the artery. There is also good reason for believing that in either of these two ways a bruised artery may become completely occluded. If the closure is produced mainly by the first method, it will be likely to occur more speedily than when it is produced solely by the second method. Generally, both of these morbid processes concur in producing the constriction or occlusion of the vessel.

Extravasation of blood within the sheath. Inflammatory swelling.

There is, however, a specimen in our Army Medical Museum, which seems to prove that complete occlusion may be produced in a bruised artery by the inflammatory process alone. It is described in the Catalogue as "A wet preparation of the popliteal artery, showing a clot formed in it from inflammation along the track of a ball which did not involve the arterial coats in the sloughing process. Amputation was performed to obviate sphacelus, and the patient recovered."[1] It is not improbable that the ball contused the vessel in its passage through the parts.

In Guthrie's case, to which allusion has already been made, the ball passed between the femoral artery and vein. The patient died, sixteen days after the injury, from gangrene of the foot and leg. After death Mr. G. obtained the specimen. The coats of the artery were not destroyed in substance, although wounded. At this spot the vessel was "much contracted in size, and filled above and below by coagula, which prevented the transmission of blood." The artery was impervious. The coats of the vein were but little injured, although it was "filled by a coagulum, and impassable," at the bruised part.[2] The constriction of the artery seems to have been largely due to the inflammatory process.

An interesting case belonging to the same category is related in the "Surgical History of the Crimean War." P. Ryan, aged 21, received a shell wound of the left ankle, and a canister-shot wound (supposed) through the left thigh, at its upper part, involving the

[1] Vide *Catalogue*, p. 457, specimen 2150.
[2] Vide *Diseases and Injuries of Arteries*, p. 242.

course of the femoral vessels, on June 8. On the 16th, incipient gangrene of the foot appeared, and the leg was amputated immediately below the knee. On the 18th, gangrene attacked the stump, on the 19th it extended up the thigh, and on the 20th, death occurred. At the autopsy "the ball was found to have passed through the thigh internally to the sheath of the femoral vessels, which it had grazed but not opened. The artery at this point was slightly contracted for about an inch in length, but pervious, and contained no coagulum, and beyond the contraction, its calibre showed no marks of inflammation. The vein, however, was not only also slightly contracted, but its internal surface was inflamed and filled with partially organized lymph, as far up as the entrance of the deep iliac vein, and downwards for about two inches from the wound. Its course was thus entirely sealed, but nothing like pus could be found in the femoral or iliac veins, nor in the venous system anywhere."[1] In this case the contraction of the artery and the occlusion of the vein appear to have occurred mainly through the agency of the inflammatory process.

We have thus related, with more or less minuteness, four cases in which the main artery of the lower extremity was bruised by the impact of a gunshot projectile, and its calibre became diminished in size in consequence thereof, at the place of injury. In two instances the occlusion was complete, but in the other two it was only partial. In two of them the accompanying vein also was obstructed either by contraction of its bore, or by being plugged up with plastic exudation or coagulated blood. In the other two, however, that channel seems to have remained open. But in all of them traumatic gangrene, commencing in the foot, occurred, and in this respect only do all of them agree. Furthermore, the mortality was very great, since three died and but one recovered. This patient was saved by timely amputation. That operation was employed in two other instances but without success. In one of these gangrene returned in the stump, and in the other death was produced by pyæmia. In Mr. Guthrie's case no operation was performed.

Gunshot contusion of femoral artery does not always induce gangrene when the vessel is occluded.

But gunshot contusion of the femoral artery, even when it is severe enough to arrest the flow of blood through the vessel, to great extent, does not always induce traumatic gangrene. The obstruction to the circulation may prove to be but temporary in its nature, and thus recovery may spontaneously take place, as appears to have happened

[1] *Surgical History of the Crimean War*, vol. ii. p. 343.

in the following instance, which occurred in the Crimean war: "Private John English, 4th regiment, age 20, on 22d June, received a wound from a musket-ball, which passed through the thigh. The wound was directly in the course of the femoral vessels. As he was reported to have lost a quantity of arterial blood, on receipt of injury in the trenches, it was feared that the femoral artery had been wounded. The temperature of the limb was sensibly diminished, and the pulsation of the arteries in the foot could not be discerned for several days. He was exceedingly restless, and complained of pain and numbness in the calf of the wounded limb. No hemorrhage, however, occurred; the limb regained its natural temperature, and he slowly recovered."[1] It is not improbable that in this instance blood was extravasated within the sheath of the artery, as happened in the case of Knoble (Case V.), and that afterwards this blood was rapidly removed by absorption.

From the foregoing observations it appears that sudden contusion of the arterial tunics, especially when produced by gunshot projectiles, and in the lower extremity, is liable to lead to disastrous consequences, either by inducing secondary hemorrhage from ulceration of the bruised part of the arterial walls, or by occasioning traumatic gangrene from occluding the vessel (more or less completely) at the place of injury.

Treatment. — When secondary hemorrhage occurs, the vessel should generally be secured in the wound by ligatures applied on each side of the bleeding orifice. If, however, the lesion of the artery is complicated with gunshot fracture, as it was in Cases II. and III., and is situated in the lower extremity, it is generally advisable to amputate the member instead of tying the injured vessel. If traumatic gangrene occurs, amputation is our sole expedient. The treatment will, however, be more fully considered in connection with secondary hemorrhage and gangrene from wounds in general.

3. LACERATED WOUNDS OF ARTERIES.

The most Striking Examples of this Lesion are afforded by those Cases in which Limbs are plucked off by Machinery or carried away by Cannon-balls. — Phenomena attending this Form of Arterial Injury. — Remarks by the Surgical Historian of the British Army in the Crimean War on this Subject. — A Case in Point. — Guthrie has related Two Cases belonging to the same Category, and described the Phenomena. — When Limbs are torn off by Machinery or by Cannon-balls, the Hemorrhage frequently but not always ceases spontaneously. — Remarks on this Subject. — An Illustrative Case. — Several Cases of a Similar Import related to the Writer during the Late War. — Dr. Eve has collected Three Cases in which the Arm was plucked off by Machinery. — On the Phenomena presented

[1] Vide *Surgical History of the Crimean War*, vol. ii. p. 343.

by them. — Lacerated Wounds of Arteries sometimes produced with a Bayonet. — The Army Medical Museum contains a Specimen of this Sort. — The Army Medical Museum also contains a Specimen in which the Popliteal Artery was torn by a Splinter of Wood. — A Case in which the Carotid Vessels were extensively torn by Goring with the Horn of a Maddened Beast. — Sometimes an Important Artery is torn without Corresponding Wound of the Integuments, *e. g.*, the Axillary Artery in reducing Old Dislocations of the Shoulder. — An Important Artery may also be torn by Broken Bone in Cases of Fracture. — Dupuytren states that this Accident is far from rare. — An Illustrative Case. — Arteries may be either punctured or lacerated by Fracture Splinters. — Traumatic Aneurisms resulting from Fracture not confined to the Leg. — Treatment of Lacerated Wounds of Arteries. — When the Arm is plucked off by Machinery, the Arteries should be tied on the Face of the Stump. — When a Limb has been stricken off by a Cannon-ball, etc., Amputation should be performed at some Higher Point if practicable. — Treatment of Traumatic Aneurism when produced by Fracture Splinters. — The Old Operation applicable to Lacerated Wounds of Arteries when produced by Splinters of Wood, etc.

Lacerated wounds of the extremities, especially when they are extensive, are not unfrequently accompanied by lacerated wounds of the main blood-vessels at the place of injury. But probably the most striking examples of lacerated wounds of arteries are afforded by those instances in which the limbs are torn off by the operations of machinery, or carried away by the passage of cannon-balls, or by the explosion of bombs. In such cases the principal arteries are generally seen hanging out of the ragged-looking stump left by the injury, and pulsating quite down to their ends, which, on examination, are found to be contracted to a point or nearly so, and obstructed by a clot of blood in such a way that, between the contraction of the vessel at its end, and the coagulum, hemorrhage from the stump is oftentimes arrested, and always greatly diminished.

Limbs torn off by machinery or carried away by cannon-balls.

On this point the surgical historian of the British army in the Crimean War, says: —

"When a limb is torn away by a round shot, the artery, main vein, and nerves will invariably, it is believed, be found to be hanging from the wound, torn off at a point much more distant from the heart than the rest of the soft parts; the end of the artery lacerated, contused, and contracted, and generally filled after a very short interval of time with a dark-colored clot for a few lines from its extremity, but above that often pulsating strongly though fully exposed to the air, as in the following instance: In the 44th regiment, on the night of 21st June, a man had his left arm carried away at the shoulder-joint. The limb was completely separated from the trunk, leaving too little of the soft parts to cover in the face of the wound. The axillary artery appeared to have bled very little, if at all, at the moment of the injury, and there was no subsequent hemorrhage. The laceration laid bare the artery and vein for full three inches of their course; the ends of these vessels for three quarters of an inch were curved, plugged with coagu-

lum, and tapering to a point; the pulsation of the artery was full to the very base of the plug of coagulum. The head of the bone was removed, the case thus becoming an amputation at the shoulder-joint, but the man died."[1]

Guthrie has related the case of a soldier, who had his arm carried away by the bursting of a shell at the siege of Ciudad Rodrigo, and who was brought to him shortly afterwards. The axillary artery as it becomes brachial was torn across, and hung down lower than the other divided parts, and pulsated up to the very extremity. Pressed and squeezed in every way between his fingers in order to make it bleed, it still resisted every attempt, although apparently by the narrowest possible barrier, which appeared to be at the end of the artery, and formed by its contraction. The canal was marked by a small red point, to which a very slight and thin layer of coagulum adhered, the removal of which, however, did not produce hemorrhage. In another case of a similar character, Guthrie cut off the end of the artery at less than one eighth of an inch from the extremity, and then it bled with its usual vigor. In both instances the vessel for that distance was contracted, so as to leave little or no canal at its orifice, and what there was, was filled by a pin-shaped coagulum.[2]

When limbs are torn off by machinery or by cannon-balls the hemorrhage frequently but not always ceases spontaneously.

But the reader must not suppose that the spontaneous arrest of hemorrhage as described by Guthrie takes place in all cases wherein the limbs are torn off by cannon-balls or by machinery, for such is not the fact. It does, however, not unfrequently take place under such circumstances.

British army in the Crimean war

Thus, with regard to spontaneous closure of the end of the lacerated vessel, and the arrest of hemorrhage, mentioned above, the surgical historian of the British army in the Crimean War, says: —

"In the largest arteries, however, as the femoral, and occasionally, though much less frequently, in smaller vessels, this did not always happen, unless aided by syncope (either the effect of the blood rapidly poured out at first, or the combined effect of hemorrhage and shock); and hemorrhage then sometimes proceeded to such an extent as to prove fatal, as in the following instance: J. Ross, 4th regiment, had his leg below the knee carried away by a round shot. He had lost much blood before a tourniquet was applied, and was so much collapsed when received at the hospital, that an operation was out of the question. The wound was

[1] Vide *Surgical History of the Crimean War*, vol. ii. p. 340.
[2] Vide *Diseases and Injuries of Arteries*, p. 224, London, 1830.

dressed and the tourniquet removed. He never rallied, and died nine days after the receipt of the injury. No further hemorrhage had taken place, though all pressure had been removed from the artery." [1]

Cases related to the writer during the late war.

During the progress of the War of the Rebellion, several cases were related to the writer by reliable medical officers who had witnessed them, wherein the ragged looking stumps of limbs that had been torn off by cannon-balls or shells bled profusely at the outset, and afterwards did not entirely cease to bleed until ligatures were applied. In some of them the loss of blood was so great as to cause a fatal result of itself, although surgical aid was promptly afforded.

Dr. Eve's cases.

In civil life the limbs are sometimes torn off suddenly, by being caught in strong, revolving machinery. Dr. Eve has collected three cases of this sort. In each of them the arm with the scapula attached was plucked completely off from the body. In each case also the lesion was produced in substantially the same way; the subject was caught by the hand or arm in powerful machinery, and then dragged quickly upwards by that member, until the body struck some solid barrier, such as a beam or the ceiling, which suddenly stopped its further progress.

The hemorrhage was not excessive in either case. It is stated that in one of them, "The artery was seen pulsating at the bottom of the wound, and was plugged up by a coagulum of blood. The vein was distended, and lay upon the torn muscles like a gorged leech." But few ligatures were required, and in one instance it seems that no vessel was tied, as "there was no hemorrhage" when the surgeon arrived.

But little or no sloughing of the lacerated tissues occurred, and each patient made a good recovery.[2]

Lacerated wounds of arteries produced by bayonet wounds.

Lacerated wounds of important blood-vessels, however, not unfrequently occur when the surrounding parts are not extensively torn. Thus, in military life, such a wound may be produced by a bayonet thrust. The Army Medical Museum contains a specimen of that nature. It shows the subclavian artery torn open by a bayonet injury for two thirds of its circumference, one fourth of an inch from the innominate.[3] This specimen proves that when an artery is wounded by that weapon, the breach in the coats of the vessel is not always of

[1] *Surgical History of the Crimean War*, vol. ii. p. 340.

[2] Vide *Eve's Surgical Cases*, pp. 579, 580. See also Sir Charles Bell's case, mentioned on p. 114 of this Section.

[3] Vide *Catalogue*, specimen 2721.

the punctured variety. It was obtained from an unknown soldier, killed at Fort Wagner, S. C.

In civil life, lacerated wounds of important arteries, without extensive injury of the surrounding parts, are produced by a considerable variety of accidents. There is a specimen in the Army Medical Museum, which shows the popliteal vessels lacerated by a splinter of wood. This injury was inflicted in a railroad accident, October 29, 1864. The patient entered hospital November 2d, and died on the 3d. His thigh was amputated at the junction of the lower thirds.[1]

In the following instance the carotid vessels were torn on an extensive scale by being gored with the horn of a maddened beast.

Case VI. *Lacerated Wound of Internal Carotid Artery; Vessel partly divided; Primary Branches of External Carotid torn off from their Trunk; but Little Bleeding at the Outset; after a Time Hemorrhage became profuse, but it was arrested by tying the Primitive Carotid; Death Thirty Hours afterwards from Inflammation of the Brain.* — A man was gored in the neck by a cow. The horn entered by the left side of the cricoid cartilage, and penetrated as far as the vertebræ; it then passed upwards on the bodies of those bones, nearly as high as the base of the skull; afterwards it came out behind the angle of the jaw, exposing, and in some degree injuring the parotid gland in its passage, and lacerating the skin of the face as high as the middle of the ear. In its course it passed beneath, and tore the internal carotid artery, and all the primary branches in front of the external carotid artery. The former vessel was not, however, entirely rent asunder, so that the general course of the artery, and its connection with the cranium remained in the usual state. *Notwithstanding the size of the vessels which had been torn, they did not immediately bleed; the wound was therefore closed and bound up.* The blood was soon observed to flow in streams down the neck, nor could any general pressure upon the wound prevent hemorrhage. In this state the man was conveyed to St. Bartholomew's Hospital, but he had lost a large quantity of blood before his arrival.

The patient was laid upon a bed, and before the wound was opened, one of the students firmly compressed the trunk of the carotid artery against the lower cervical vertebræ. We found upon the first inspection of the wound, that this pressure prevented any hemorrhage; yet, upon the occasional motions of the patient, and upon accidental variations in the pressure made on the vessel, the blood gushed from the bottom of the wound so suddenly, and in such quantities, as to prevent any accurate examination. The man was very unquiet; he complained much of the pressure, and was greatly distressed by a sensation of suffocation, which compelled him constantly to expectorate. Under the

[1] *Catalogue*, specimen 3761.

circumstances, our first endeavor was to tie the more superficial arteries; but the edges of the wound being lacerated, the first ligatures which we endeavored to make tore away portions of the flesh, and did not secure the vessels.

The situation of the patient became every moment more desperate; he really seemed choking, his extremities became cold, and his pulse scarcely to be felt; his struggles also, which could not be controlled, made the pressure on the trunk of the artery very precarious. It was deemed necessary to enlarge the wound to get at the trunk of the carotid artery, and an incision was made between the track of that vessel and the trachea, in a direction parallel to each of these parts. Mr. Abernethy had now the power of passing his finger beneath the trunk of the carotid artery; and of effectually compressing it between that finger and his thumb, which was placed opposite to it, upon the integuments of the neck.

Finding that the moment he remitted the pressure of the carotid, the blood gushed out from so many orifices, and in such a torrent from the bottom of the wound, he resolved to pass a ligature round the trunk of the carotid at the part where he had been compressing it, and which was about an inch below its division.

The ligature was applied. The bleeding was immediately arrested, and did not recur; but the patient died about thirty hours after the operation, from inflammation of the brain.

It was found that the internal carotid artery was partly torn across, and that the primary branches of the external carotid artery had been torn off from the trunk.[1]

In this case the hemorrhage appears to have been delayed or retarded until reaction supervened, and vascular excitement made its appearance.

Arteries lacerated without corresponding wounds of integuments.

Again, lacerated wounds are sometimes produced in the coats of an important artery, without there being any breach of the integuments. For example, the main artery of a limb has occasionally been torn, either partially or completely across, by injudicious efforts to reduce an old dislocation. In such a case the blood escapes from the calibre of the vessel, through the rent of its walls, into the connective tissue, and there being no external outlet, forms a more or less deeply seated swelling at the place of injury, filled with blood and pulsating syncronously with the heart, called a spurious or traumatic aneurism. The axillary artery is especially liable to sustain this accident when too much force is used in reducing certain forms of old dislocation of the humerus at the shoulder. Thus, a case is related in the

[1] Vide *Abernethy's Surgical Observations*, vol. ii. p. 72 et. seq., Am. ed., 1811.

"Répertoire d'Anatomie et Physiologie," by M. Faubert, surgeon to Hôtel Dieu at Rouen, in which the attempt to reduce a dislocated shoulder-joint produced a rupture of the axillary artery, gangrene, and subsequently, the death of the patient.[1] Professor Hamilton has collected in his excellent "Treatise on Fractures and Dislocations," all or nearly all the instances on record in which this accident occurred, and to that work the reader is respectfully referred for additional information on this subject.[2]

Furthermore, an important blood-vessel is not unfrequently lacerated in a limb, without corresponding wound of the integuments, by a fragment of bone, in cases of simple fracture. We have elsewhere shown that a large artery may receive a punctured wound from a sharp fracture splinter, by referring to a specimen belonging to the Army Medical Museum, in which the popliteal artery was punctured by a sharp spicula in a case of gunshot fracture of the femur in its lower third. In cases of simple fracture the blood-vessels are more liable to be punctured by the fragments when the leg is broken, than when the injury occurs in any other region of the body. J. L. Petit has related a case in which the anterior tibial artery was laid open by the sharp edge of the broken tibia. In such instances blood is extravasated from the lacerated vessel into the surrounding connective tissue, and a tramautic aneurism is formed. Dupuytren states that this accident is far from rare, and that he had witnessed it as many as seven times since 1806.[3]

This accident also constitutes a very serious complication of simple fracture, as is well shown by the following instance: —

Case VII. — *Simple Fracture of the Leg (both Bones), followed by Traumatic Aneurism from Laceration of the Peroneal Artery by an Osseous Fragment; Amputation; Death by Pneumonia some Time afterwards.* — Claude-Gérard Calaz, aged 55, of small stature, and feeble power, having the legs bowed forwards, was thrown from a ladder, and broke his left leg, in 1806. When brought to the hospital, it was evident that the left tibia was fractured very obliquely below its upper third, the upper fragment threatening to penetrate the skin. The limb was placed in a favorable condition and position, and for the first week all went on satisfactorily and as usual, with the exception of a considerable tendency to riding of the fractured extremities of the tibia, attributable, apparently, to the curvature of the bones. But towards the end of a fortnight, the patient began to complain of pains in the calf of the leg, which he ascribed to

[1] Vide *Eve's Surgical Cases*, p. 529.
[2] *Fractures and Dislocations*, p. 554.
[3] *Lesions of the Vascular System*, p. 3.

the tightness of the bandages, and experienced relief when they were slackened. After the lapse of a few days, however, the same suffering returned; but, when the limb was examined towards the close of the month, there was no appearance to account for this continued pain. It went on increasing, nevertheless; and in the course of a few days afterwards, swelling, accompanied by tension and a blueish appearance, was evident about the middle of the leg. On further examination, a sort of tremulous movement, increasing and diminishing alternately, became perceptible, such as might have been taken for the pulsation at the ends of the fingers; this was observed on the front as well as the back part of the leg. This swelling, moreover, was observed to diminish a little in volume, and to lose its regular pulsating character, when the popliteal artery was compressed; but all the signs above enumerated were restored when the compression was removed from the artery, — circumstances which left little doubt as to the true nature of the tumor. On prosecuting the examination, the popliteal artery was found to be sound; the inference, therefore, was that the aneurism was associated with one of the arteries of the leg. It was evident that death must ensue unless some decided step were taken to save the patient; and the alternative of amputating or placing a ligature on the femoral artery, held out but little hope, in consequence of his bad constitution and enfeebled state.

The fracture, however, appeared to be almost entirely consolidated, and so the apparatus was removed; but in less than four hours the rapid extension of the swelling determined the question in favor of immediate amputation, preparatory to which an incision into the leg cleared up any remaining doubt on the subject, by giving exit first to some dark infiltrated blood, and subsequently to a bright arterial stream. The operation was performed through the thigh, and by a circular flap. The patient went on favorably for a time, till he was attacked by pneumonia, under which he sank and died.

Examination of the Amputated Limb. — A careful dissection was made, and the aneurismal sac exposed; the soleus muscle formed its superficial boundary, and laterally it was limited by the deep layer of muscles of the leg. It projected anteriorly through the lacerated interosseous ligament, opposite the seat of fracture, so as to press forwards the anterior muscles of the leg. It was filled with solid clots. The source whence the extravasation proceeded was found to be an irregular lacerated opening in the peroneal artery, caused by the sharp fragments of the broken fibula having penetrated it. This vessel was pervious as far as the seat of injury, but entirely obliterated below it. The tibia was firmly united, and a longitudinal fracture was observed extending upwards from the point where it had been broken across.[1]

[1] Vide Dupuytren, *On Lesions of the Vascular System*, pp. 4, 5, 6, Sydenham Soc. ed., London, 1854.

With regard to the several lesions which arteries sustain from fragments of bone in cases of fracture, it appears from the foregoing discussion of the subject that the coats of the vessel may either be simply punctured by a sharp spicula, or lacerated by a larger fragment to such extent as to lay the vessel freely open, and immediately produce a copious extravasation of blood into the surrounding structures. When the artery is merely punctured, and especially when the bony spicula remains sticking in its walls, hemorrhage in great quantity does not occur until the wounded part of the vessel has had time to ulcerate, that is, until the secondary period has arrived.

Arteries punctured or lacerated by fracture splinters.

Traumatic aneurisms resulting from fracture are not confined to the region of the leg, but are found in any part of the body where an artery lies sufficiently near the bone to be pierced or torn by its broken fragments. Thus, in one of Mr. Moore's cases, the humerus was fractured, and the extravasation of blood occurred in the arm; in another case, under the same gentleman's care, the femur was broken and the effusion of blood took place in the thigh; and "Mr. Busk and Mr. Curling have each put upon record a case in which a traumatic aneurism formed upon the ophthalmic artery as a consequence of fracture of the base of the skull."[1] It is, however, unquestionably true that fractures of the leg are attended with traumatic aneurism much more frequently than fractures occurring in any other region of the body.

Treatment of Lacerated Wounds of Arteries. — In cases where a limb has been torn or plucked completely off from the trunk by powerful machinery, it is advisable to tie the principal vessels on the face of the stump. The main arteries should always be secured by ligature, whether they bleed or not, when the surgeon arrives. The integuments should then be drawn together and the case treated as an incised wound. A good result has not unfrequently been obtained in these cases by this plan of treatment. As a rule no tissue is cast off by sloughing or ulceration, unless it has happened to be bruised by striking against some solid object, such as the ceiling or a beam.

But when a limb has been stricken off by a cannon-ball, or bomb, or any other form of shell, and thus its blood-vessels have become lacerated, it is always advisable to amputate the member at some higher point, if practicable, since the tissues of the limb are liable to be bruised, and more or less considerably disintegrated and infiltrated with blood

Amputation when a limb has been stricken off by a cannon ball, etc.

[1] Vide *Holmes' System of Surgery*, vol. iii. pp. 443, 447.

to some distance above the breach, as I once found on examining the ragged-looking stump of a fore-arm that had been stricken nearly off by the premature discharge of a cannon. The tissues of this stump appeared to be but slightly injured, away from the wounded surface, until they were cut into, when they were found to be ecchymosed and disintegrated, as mentioned above, nearly up to the elbow-joint. The operation was therefore performed in the continuity of the arm.

Treatment of traumatic aneurism when produced by fracture splinters.

When a traumatic aneurism forms in consequence of an artery being lacerated by a fracture splinter, it should be treated either by securing the vessel at the place of injury with two ligatures, one being applied on each side of the bleeding orifice, or by amputation, or by ligature of the main trunk of the artery at some distance above the wound, on the plan of Hunter. The remarks already made concerning the treatment of traumatic aneurism when produced by puncture with sharp spiculæ of bone, are all applicable in this place; and the subject will be more fully discussed in the chapter devoted to the special consideration of traumatic aneurism.

When an important artery has been lacerated by a splinter of wood, for example, in a railroad accident, or by other means of a similar nature, it is generally advisable to secure the vessel at the place of injury with two ligatures, applying one of them on each side of the breach in its coats, unless the surrounding parts are damaged in such a way as to render amputation necessary, the preservation of the member being put out of the question by the nature and extent of the injury.

When, however, it is impracticable to tie the bleeding vessel at the place of injury, the artery from which it springs should be ligated as near the wound as possible.

4. GUNSHOT WOUNDS OF ARTERIES.

Note. — The Resiliency of Certain Arteries is much greater than is usually supposed. — Illustrative Cases quoted from "Surgical History of British Army in Crimean War."— Dr. Otis' Remarks on the same Subject. — Still, Gunshot Breaches not unfrequently occur in the Walls of Important Arteries. — The Velocity of the Projectile must generally be great in Order to produce this Lesion. —When the Velocity is retarded, Contusion may occur.— Gunshot Wounds of Arteries are generally contused and lacerated in their Nature. — Classification of Gunshot Breaches in the Walls of Arteries. — 1. *Partial Division.* — 2. *Complete Division.* — The Number of Cases belonging to this Category that was treated during the Late War was comparatively very small. — Dr. Otis' Observations on this Point. — This Accident is practically confined to the Following Regions, namely, the *Neck*, the *Head*, and the *Extremities*. — Gunshot Wounds of the Great Arteries of the Abdomen and the Thorax are seldom seen by the Surgeon, because such Wounds usually prove quickly fatal from Hemorrhage. — Of Partial or Incomplete Division. — Two Varieties recognized. — In one of them the Side of the Artery is carried away, in the other the

Vessel is perforated by the Projectile. — A Case in which the Axillary Artery was wounded by a Musket-ball; Primary Hemorrhage very profuse; Death from Secondary Hemorrhage Eleven Days afterwards; the Old Operation was performed when the Patient was *in extremis*; the Patient died a Few Minutes afterwards; Autopsy; a large Semicircular Portion of the Artery corresponding to about Half its Calibre had been cut out by the Ball. — A Case in which the Posterior Tibial Artery was partially divided by Gunshot Wound; Profuse Secondary Hemorrhage on the Seventeenth Day; the Vessel was tied in the Wound on the next Day; Death occurred a Few Hours afterwards from Exhaustion. — This Patient was weakened from Chronic Diarrhœa when the Wound was inflicted. — Partial Division of Large Arteries very dangerous; the Reasons presented. — A Case in which the Popliteal Artery was perforated by a Conical Ball, contributed by Professor Post; a large Traumatic Aneurism formed; Amputation Eight Days after Injury; Recovery; Popliteal Vein not wounded. — Consecutive Gangrene less likely to occur from Partial than from Complete Division of Arteries; the Reasons stated. — Venous Congestion of the Foot and Leg, and how it was produced in this Case. — The Consequences of Partial Division of Large Arteries by Gunshot Projectiles. — The Breach in the Walls of the Vessel cannot close spontaneously. — The Primary Hemorrhage apt to be profuse, and liable to prove fatal unless restrained by Surgical Art. — Or a Traumatic Aneurism may be formed under Favoring Circumstances; those Circumstances enumerated. — In such Cases the Bleeding continues internally although it has ceased externally. — Treatment. — When a Large Artery is partially divided, it should always be secured with Proximal and Distal Ligature, in the Wound when practicable. — The Operation should be promptly performed. — It should not be considered only as a Measure of Last Resort. — It should generally be deemed preferable to any other Expedient in such Cases. — On Complete Division of Arteries by Gunshot Projectiles. — A Large Number of Illustrative Cases will be related. — A Case contributed by Dr. Clendenin, in which the Femoral Artery was divided (probably) near Poupart's Ligament; but little Bleeding at the Time; Secondary Hemorrhage on Sixth Day; Compression and Liquor Ferri Persulph. employed without Success; Ligature of External Iliac Artery; no Bleeding afterwards; Death from Exhaustion on Seventeenth Day subsequent to Operation; the Operation itself answered a Good Purpose, but the Patient never rallied from the Loss of Blood occasioned by Secondary Hemorrhage. — The Bleeding not unfrequently ceases spontaneously when Large Arteries are completely divided by Gunshot Projectiles. — The Secondary Hemorrhage in this Case appears to have been excited by going to Stool. — Some of the Bad Consequences of employing the Persulphate of Iron and Pressure to restrain Hemorrhage from Large Arteries are shown by this Case. — These Agents proved insufficient to control the Bleeding. — In such Cases we should not waste Valuable Time in trying Inefficient Agents. — Other Evils resulting from the Use of Ferri Persulph. and Pressure stated. — A Case of Gunshot Wound of the Thigh near its Middle severing the Femoral Artery; Vessel tied both proximally and distally at End of Twenty-four Hours; Secondary Hemorrhage Six Days after Injury; it was controlled by Pressure; Gangrene: Death on Eleventh Day; Autopsy; Femoral Vein also found to be ligated; Distal Ligature of Artery had separated; the Secondary Bleeding occurred from the Distal Orifice; Bad Consequences of Pressure in this Case. — Consequences of tying the Femoral Vein in this Case; it probably assisted in producing the Consecutive Gangrene. — The Primary Hemorrhage was considerable, and although it did not prove immediately fatal, it in Reality contributed much to that Issue. — A Case of Gunshot Wound of the Femoral Artery near the Middle of the Thigh contributed by Dr. Clendenin; Hemorrhage very profuse; Vessel ligated on the Spot; but the Patient had lost so much Blood that he died Twenty-eight Hours afterwards; the Autopsy showed that the Femoral Artery was completely divided, and that the Femoral Vein was not injured. — Another Case of Gunshot Wound of the Femoral Artery near the Middle of the Thigh, contributed also by Dr. Clendenin; Hemorrhage very profuse, and the Patient died before he could be carried to the Field Hospital, a Distance of about One Mile. — Dr. Baylor's Case, in which the Femoral Artery was severed by a Minie Ball without Consecutive Hemorrhage. — Summary of the Foregoing Cases, Five in Number, in which the Femoral Artery was severed by Gunshot Projectiles. — Primary Hemorrhage slight in Two, considerable in One, and Fatal in Two Instances. — Secondary Hemorrhage occurred in Two Instances. — Consecutive Gangrene occurred in Two Instances. — All of them died; Two of Primary

Hemorrhage; One of Exhaustion following Secondary Hemorrhage; One of Gangrene; and One of Secondary Hemorrhage and Gangrene. — Duration of the Cases severally stated. — A Case of Gunshot Wound of the Popliteal Artery, contributed by Dr. Clendenin; Hemorrhage at first Profuse, but it ceased spontaneously; Consecutive Gangrene of Foot and Leg; Amputation on Thirteenth Day after Injury; Recovery. — Another Case of Gunshot Wound of the Popliteal Artery mentioned by Dr. Clendenin. — A Case of Gunshot Wound severing the Popliteal Artery; Hemorrhage ceased spontaneously; Gangrene of Foot and Leg occurred in Four Days; Amputation and Death from Exhaustion on the Fifth Day afterwards. — Septæmia from the Gangrenous Leg occurred in this Case. — Primary Amputation should have been performed. — A Case of Gunshot Wound of the Knee-joint severing the Popliteal Artery. — Summary of Four Popliteal Artery Cases. — In all of them the Bleeding ceased spontaneously. — In Three of them Consecutive Gangrene is known to have occurred. — The Reasons for such a Result stated. — Two Patients died and Two were saved by Timely Amputation. — Next, Two Cases are related in which Gunshot Wounds severing the Posterior Tibial Artery were followed by Gangrene. — In both of them the Bleeding ceased spontaneously. — Gunshot Wounds of the Middle and Upper Thirds of the Leg which sever the Posterior Tibial Artery, are generally followed by Gangrene. — The Reasons for such a Result stated. — On Gunshot Wounds dividing the Axillary Artery, with Three Illustrative Cases. — Another Case also referred to. — Primary Hemorrhage generally does not prove fatal in Cases where the Axillary Artery is completely divided by Gunshot Projectiles. — The Bleeding generally ceases spontaneously in such Cases. — Summary of these Four Cases. — Consecutive Gangrene occurred in One Instance, Traumatic Aneurism in One Instance, both proving fatal, and the remaining Two Cases recovered. — On Gunshot Wounds dividing the Brachial Artery, with Three Illustrative Cases. — Two of them were contributed by Dr. Clendenin. — Summary of the Three Cases. — In all of them the Primary Bleeding stopped of itself. — In None of them did Gangrene occur. — Two recovered and One died of Pyæmia. — A Case of Gunshot Wound severing the Internal Mammary Artery, contributed by Dr. Clendenin. — Disastrous Consequences of Styptics and Pressure in this Case. — A Case in which the External Carotid Artery was probably severed by a Pistol-ball, contributed by Dr. Sanford B. Hunt, late Surgeon U. S. Volunteers. — The Hemorrhage was arrested by Digital Pressure applied in the Wound, and the Patient recovered. — Concerning the Value of Local Pressure for the Temporary Control of Certain Forms of Bleeding, and the Way in which it should be applied for such a Purpose. — General Summary of Twenty-three Cases of Gunshot Wounds of Arteries which we have related or mentioned. — Gunshot Wounds severing Large Arteries very dangerous. — The Principal Sources of Danger are Hemorrhage and Consecutive Gangrene, but especially the Latter. — Cases of Partial Division of Arteries by Gunshot Projectiles come under the Surgeon's Notice more frequently than Cases of Complete Division. — Dr. Otis' Remarks on this Point. — Dr. Otis' Remarks on the Treatment of Gunshot Wounds of Arteries. — The Author's Observations on the same Subject.

Gunshot breaches in the walls of important arteries not unfrequently occur.

Notwithstanding the wonderful resiliency of the arteries,[1] especially those of the extremities, which oftentimes enables them to escape serious injury even when they appear to lie exactly in the track of wounds made by gunshot projectiles, it not unfrequently happens that they sustain

[1] The principal causes of this resiliency have already been pointed out (vide p. 12). Concerning the remarkable extent of it, the surgical historian of the British Army in the Crimean War justly observes: "The amount of this resiliency of the large arteries of a limb is much greater than is usually supposed. Thus, in a soldier of the 56th Regiment, a fragment of shell passed through the ham, between the artery and the bone, without injuring either, although it was much too large to have done so without displacing the vessel. The man afterwards died of diarrhœa. In the 9th Regiment a similar case occurred, but in it a portion of the bone was scooped out by the missile, and the man recovered. In the 47th Regiment, a large piece

Resiliency of certain arteries much greater than is usually supposed.

solutions of their continuity from being struck by such projectiles. Observation has shown that arteries may be wounded in such a way as to open their calibre at once by musket, rifle, carbine, and pistol-balls, by case-shot and by fragments of shells. It seems, however, to be necessary for the accomplishment of such a result, that the missile should have a high degree of velocity at the moment when it strikes the vessel. Hence it happens that bullets are much less likely to penetrate the arteries after they have passed through the compact structure of the long bones in the extremities, than before they have made such passage through osseous tissue. If the velocity of the projectile has been considerably retarded ere it impinges against the artery, it may bruise its walls (see *Contused Wounds of Arteries*), and in that way may occasion about as much damage to the patient as it would if it penetrated the vessel.

Gunshot wounds of arteries contused and lacerated in their nature.

The breaches or solutions of continuity, inflicted upon the walls of blood-vessels by gunshot projectiles, are essentially contused and lacerated in their nature, and usually present some of the features which belong to each of these classes of injuries. They can therefore be most conveniently considered in this place, that is, immediately after the discussion concerning the contused and lacerated wounds of arteries.

Classification of gunshot breaches in the walls of arteries.

On taking a comprehensive view of the various breaches in the walls of blood-vessels, which have been ascertained to be directly produced by gunshot projectiles, we find that they may be divided into two principal groups: —

1st. Partial or incomplete division of the vessel considered as a tube for the transmission of blood, and

2d. Complete division of the same.

We also find, on attentively studying the details of this subject, that each of these groups presents peculiarities in respect to phenomena and consequences, of so much importance in both a scientific and practical point of view, as to demand their separate consideration. We shall, to some extent, pursue that plan in the following pages.

of shell passed through the upper third of the thigh, between the artery and the bone, but injured neither, and recovery took place." (*Surgical History of the Crimean War*, p. 340.)

On the same subject, Dr. Otis remarks in Circular No. 6 (p. 39), "A number of drawings at the Army Medical Museum, exhibiting the course of balls directly in the track of the great vessels of the neck or of the limbs, illustrate the fact so well known to military surgeons, of the great resiliency of the large arteries."

But before proceeding further, we should remark that the number of cases of gunshot wounds of arteries which have been treated during the late War of the Rebellion, is comparatively very small. On this point, Dr. Otis observes: "The number of cases reported under this head is extremely small. In the campaign of the Army of the Potomac, from the Rapidan to the James, in May, June, and July, 1864, of a total of 36,508 gunshot wounds, only twenty-seven belonged to this category. The cases of compound fracture complicated with injuries of the large vessels, the cases in which limbs are carried away by solid shot or shell, and the cases in which all the tissues of a limb are disorganized by contusion from a large projectile, and the vitality of the arteries is destroyed, are all returned under other heads. Those only are included in which the canal of a large vessel is primarily opened, and in which this is the principal accident. Such cases are to be sought for among the dead on the battle-field, rather than in the field hospitals." [1]

Number treated during the late war comparatively small.

Dr Otis' remarks.

Again, in nearly all the cases where an artery of considerable size has been opened by a gunshot projectile, which are brought to the surgeon for treatment on the field of battle, the injured vessel is found to be situated either in the extremities, or in the neck, or in the head, but most frequently in the extremities. Gunshot wounds of the great arteries of the abdomen and the thorax fail to come under the notice of the military surgeon, not because these vessels escape all injury, but because whenever they are opened, death usually very speedily ensues. I am fully convinced from personal observation, that these vessels are frequently wounded in battle, that such injury is, for the most part, very quickly followed by death from hemorrhage, and that this form of gunshot lesion should be ranked as one of the principal causes of sudden death in warfare. The subjects of this form of gunshot injury almost always perish from hemorrhage before they can be taken up from the field, and hence they are generally reported as killed on their company rolls.

Neck, head, and extremities.

Abdomen and thorax.

Of Partial or Incomplete Division of Arteries by Gunshot Projectiles. — This lesion presents itself in two principal forms. In one of them the side of the arterial tube has been carried away by the missile, but in the other the vessel has been perforated through and through. Of these the former occurs more frequently than the latter. The former is met

Varieties of partial or incomplete division.

[1] Vide *Circular* No. 6, pp. 38, 39.

with in vessels presenting much variety in respect to size; the latter only in large ones. But the consequences of the wound of the artery are substantially the same in both instances.

We shall next proceed to relate several cases of gunshot wounds, in which important arteries were incompletely divided, making passing comments upon some of them, and then shall briefly discuss the consequences and treatment of this lesion.

The following case presents us with an excellent example of partial division of the axillary artery by a cylindro-conoidal bullet: —

Case VIII. *Wound of Axillary Artery by a Musket-ball; Death from Secondary Hemorrhage Eleven Days afterward;* related by H. J. Phillips, M. D., U. S. A., in charge of Post Hospital, Mobile, Ala., in the "Medical and Surgical Reporter," Feb. 17, 1866, pp. 125, 126. — Private William Hall, aged 19, Company H, 15th U. S. Infantry, admitted on the night of the 11th of January, 1866. He was accidentally wounded on that date, whilst lying in his tent, by a comrade who was handling a loaded musket. The ball entered his right side, just below the cartilages of the false ribs, fracturing, in its passage, the eighth rib; it then emerged, and entering the axilla, traversed the arm, and passed out posteriorly at the top of the shoulder.

The humerus was not touched. Before admission into the hospital, he is said to have lost a *bucketful of blood.* At the time of admission he was in a state of syncope, and unable to speak; was almost pulseless, with cold extremities. Powerful stimulants were immediately administered. There was very slight hemorrhage from either wound.

Primary hemorrhage very profuse.

He continued to improve steadily until the morning of the 20th, when he was attacked with profuse hemorrhage, which came from the neighborhood of the axillary artery. He lost about fifteen ounces of blood. The usual compression was applied, and the hemorrhage ceased.

On the morning of the 21st, a second hemorrhage occurred, by which he lost about twenty ounces of blood.

On the 22d, the prostration was so extreme, and the prospect of controlling the continual oozing so remote, that a consultation was held, and it was determined to put him under the influence of chloroform and tie the artery. A very small quantity of the vapor sufficed, and after a great deal of difficulty, owing to the great swelling and purulent matter in the wound, the artery was secured in a very able manner by Dr. Coale, U. S. Volunteers.

Operation *in extremis.*

During the operation several pieces of cloth were extracted, and also two pieces of substance which had the appearance of portions of an artery, and which subsequently proved to be such. On the extraction of the cloth, hemorrhage *per saltum* commenced, which, however, was easily controlled by pressure on the subclavian above the clavicle, by

means of a door-key. The patient survived the operation a few minutes.

Autopsy. *Post-mortem examination*, twenty-four hours afterward, revealed the following facts: *A large semicircular portion of the axillary artery, corresponding to about half the calibre of the vessel, was cleanly cut out by the ball; the humerus and the brachial plexus were uninjured;* the lower dissection showed the fractured rib, with suppurating soft parts, corresponding to the course of the projectile.

Remarks by the Reporter of the Case. — The most important fact connected with the case is the great length of time before secondary hemorrhage took place, namely, nine days after the accident. No doubt the cloth was driven into the artery, and possibly by some movement on the part of the patient afterward, or from suppuration of surrounding tissues, this and the coagula were dislodged. Almost invariably such a wound in an artery of this calibre would cause death in less than five minutes. The artery in this situation may be considered one of the *first order*. The aperture was only one inch below where it is called subclavian.

The writer, however, does not by any means feel certain that in this case the cloth was driven into the artery, for, if it was, how could the primary hemorrhage have been so very profuse?

The next case is an instance of gunshot wound involving the posterior tibial artery and partially dividing it. Secondary hemorrhage supervened on the seventeenth day.

Case IX. *Gunshot Wound of Leg injuring Posterior Tibial Artery; Profuse Secondary Hemorrhage on the Seventeenth Day; tied the Artery in the Wound on the next Day; Death from Exhaustion a Few Hours afterwards;* reported by Dr. W. B. Little, Surgeon 32d N. Y. Volunteers, in the "American Medical Times," Feb. 28, 1863, p. 101. — Colonel Roderick Matheson, commanding the 32d regiment N. Y. Volunteers, was wounded in the battle of Crampton Gap, Md., September 14, 1862, the ball passing through the calf of the right leg, fracturing the fibula in its course.

The wound was treated with cold water dressings. Six days after the wound was received, a slight hemorrhage of dark-colored blood occurred, and again two days after, it was repeated; the whole amount lost at both bleedings did not exceed four fluid ounces. No further bleeding took place until the seventeenth day, when a more profuse hemorrhage occurred, the quantity lost not exceeding one pint, not being sufficient to induce syncope. The next day, chloroform having been administered, the coagulum was removed; considerable hemorrhage followed, coming, as was soon ascertained, from the posterior tibial artery. It was now determined to enlarge the wound and tie the artery, which operation was

accordingly performed. *On reaching the artery it was found not divided, but a portion of one side, to the extent of nearly an inch, was carried away;* a ligature was placed both above and below the wound in the artery, a few pieces of bone removed from the fractured fibula, and the patient placed in bed. Symptoms of great prostration being present, every effort was made to rally him, but without avail. He lived but a few hours after the operation was completed.

The chloroform was very carefully administered, the precaution being taken to stimulate the patient previous to its inhalation.

The previous health of Colonel Matheson had not been good. At Harrison's Landing, during the campaign on the peninsula, and after returning to Alexandria, he had suffered from diarrhœa, in consequence of which he was enfeebled at the time of receiving the wound.

The foregoing account has been condensed from the published report.

Until the performance of the operation it seems it was supposed that some vessel smaller than the posterior tibial was wounded.

Comments. — The partial division of *arteries having a considerable size* is very dangerous to life. The orifice in the walls of the vessel gapes open, through the agency of the elastic tissue contained in the arterial tunics; diminution in the calibre of the vessel at the place of injury by contraction of the muscular tissue contained in its coats cannot occur; retraction of the injured portion into the sheath cannot take place; an internal coagulum, or clot within the vessel, cannot be produced. The external coagulum is so loosely adherent to the orifice in the artery, that sooner or later it is certain to become displaced, and then either a traumatic aneurism will be formed, or the hemorrhage will burst forth externally and destroy the patient's life, unless surgical assistance is promptly afforded.

Partial division of large arteries very dangerous.

The following case affords a good example of *perforation* of an arterial tube having a large size, by a cylindro-conoidal bullet. It has been contributed by Professor Alfred C. Post: —

An instance of gunshot perforation of an artery related.

Case X. *Gunshot Wound of Popliteal Space, perforating Popliteal Artery; Large Traumatic Aneurism; Tissues of Posterior Part of Leg extensively infiltrated with Blood; Popliteal Vein not injured; Amputation Eight Days after Injury; Recovery.* — Henry Schatt, aged 30, wounded March 25, 1865, admitted into Mount Pleasant Hospital, under charge of Dr. Allen, April 2. He had a gunshot wound of the left thigh. A conical ball had passed through the popliteal space from without inward, injuring the popliteal artery. On the day of his admission, the thigh

was amputated by Acting Assistant Surgeon Herman Craft, who performed the circular operation. Very little blood was lost. Anæsthesia was induced by inhalation of the vapor of a mixture of equal parts of ether and chloroform. There was good reaction. The toes of the amputated limb were blueish; the foot was cold, and covered with blueish and purple spots. The entire leg was greatly swollen; the superficial veins were engorged. Small veins on the inner surface of the thigh were somewhat discolored; the integument presented a yellowish color. The pulse of the patient at the time of the operation was small, sharp, and frequent. The face was pale, and the tongue coated. *The popliteal artery was found to have been perforated, and nearly surrounded by a large traumatic aneurism.* The tissues of the posterior part of the leg were infiltrated with blood down to its middle third. The popliteal vein was not injured. There was a slight fracture of the inner part of the head of the *tibia*. After the operation the edges of the wound were approximated with strips of adhesive plaster, and cold water dressings were applied.

Present condition, May 31st. — The patient is recovering; there is a long tubular sequestrum, which is beginning to loosen. This is the only surviving case of seven amputations of the thigh performed in Mount Pleasant Hospital since March 25th.

Comments. — Although in this case the toes of the injured limb were blueish in color, the foot cold, and marked with blueish and purple spots, it does not appear that gangrene had yet occurred, when amputation was performed. Now, it is well known that gunshot wounds involving the popliteal artery are exceedingly apt to be followed by gangrene of the foot and leg. This fact will be rendered sufficiently apparent further on in this essay. Why then did gangrene not occur in this case? Amputation was not performed until the lapse of eight days after the wound was inflicted. Surely this period afforded sufficient time for the occurrence of mortification, unless some special reason existed for its non-appearance. In my opinion such a reason did exist in this case. The artery having been *perforated* by the bullet, was therefore only partially divided; its continuity was, in some degree, still preserved; the blood continued to flow in it, to some extent, beyond the place of injury in precisely the same way that the blood continues to flow in an artery beyond the seat of a spontaneous aneurism having a sacculated shape; and thus, notwithstanding that a great tumefaction made its appearance in the limb, and the traumatic aneurism in the popliteal space had a large size, all of which served to embarrass the circu-

Consecutive gangrene less likely to occur from partial than from complete division.

lation in the parts below the knee, the vitality of the foot and leg was not entirely destroyed, when the thigh was amputated.

The blue color and the engorgement of the superficial veins of the leg were occasioned by the swelling, especially that portion of it which existed in the popliteal space, because it compressed the popliteal vein, which, by the way, was not injured by the projectile, and thus retarded the flow of the venous blood back towards the heart. But the swelling of the leg, which was occasioned by the infiltration of blood beneath the deep fascia, also contributed materially to the production of the engorgement of the veins of the surface. The inelastic and unyielding nature of this fascia enabled the blood extravasated among the deep structures to exert so much pressure upon the veins of the interior of the leg, as to prevent the return of blood through them, and the circulating fluids were therefore compelled to seek channels situated beyond the range of this compression, that is, external to the deep fascia, or on the superficies of the limb. Venous congestion.

In the history of the case it is mentioned that this patient was the only one who survived out of seven amputations of the thigh, performed at Mount Pleasant Hospital, between March 25 and May 31, 1865. The fact is not stated, but still I have no doubt that these operations were all performed during the secondary period, and it serves to illustrate the terrible mortality which attends upon secondary amputation of the thigh, performed in its continuity for gunshot injuries, especially when the patients have been subjected to the fatigue of transportation from distant points before the operation. The subjects of these operations must have been wounded either in front of Petersburg, or in the engagements which occurred between that place and Appomattox Court-house, where General Lee surrendered, and must have been conveyed from those places to general hospital in Washington, a distance of several hundred miles.

Consequences. — When an artery of considerable size has been partially divided by a gunshot projectile, the orifice in its walls never closes spontaneously, for reasons which were given in our comments on the case of Colonel Matheson (No. IX.), and if the track of the projectile in the neighboring parts remains open sufficiently to allow unrestrained communication between the orifice in the vessel and the exterior of the body, or the interior of one of its great cavities (*e. g.*, that of abdomen or thorax), the subject perishes from hemorrhage after a Consequences of partial division of large arteries by gunshot projectiles.

period generally brief, but varying in duration with the magnitude of the wounded vessel and the size of the orifice in its walls, unless surgical aid is seasonably afforded.

Bleeding continues internally although it has ceased externally.

But when the track of the projectile becomes plugged up with coagulated blood, or filled up with some foreign body, or closed at some point from the sliding by each other of some of the planes of muscle or fascia, occurring in consequence of changing the posture of the wounded part, or when the external orifice is closed by pressure, the escape of blood upon the exterior of the body becomes arrested thereby. The hemorrhage, however, does not in reality cease when this has occurred; for it becomes internal instead of external. The blood continuing to be poured out from the open mouth of the wounded vessel with each pulsation, into the surrounding parts, and finding no vent, goes on accumulating there, and thus forms a traumatic aneurism, and may lead to the same disastrous issue as was witnessed in the cases just related, by exhausting the patient with frequently recurring hemorrhage, or by necessitating amputation.

Proximal and distal ligatures in the wound.

Treatment. — When a large artery has been partially divided by a gunshot projectile, the best plan of treatment consists of securing the wounded vessel at the place of injury by two ligatures, applying one of them on each side of the orifice in its walls. When this operation is not practicable, it is advisable as the next best course to tie the main arterial trunk at some distance from the wound, but as near to it as possible. But to be of service to the patient, these operations must be promptly performed. They should not be delayed until the patient is already nearly dead. They should not be considered as the remedial measures of last resort, and to be used only when all other means of arresting the external bleeding have failed. They should be used as soon as practicable after the injury, for the purpose of stopping the *internal* as well as the *external* hemorrhage. I am thoroughly persuaded that such a course would redound much to the credit of the surgical art; for by pursuing it some lives at least may be saved that would otherwise be lost.

Complete division of arteries by gunshot projectiles.

On Complete Division of Arteries by Gunshot Projectiles. — Some small blood-vessels are severed by the bullet in almost all cases of gunshot wounds, and this occurrence but seldom gives rise to troublesome hemorrhage, or any other bad consequences.

We shall now proceed to relate a considerable number of cases in which various large arteries were completely divided by small-arms projectiles. In the following instance there is but little doubt that the *femoral artery* sustained such a lesion near its origin. The history of it was contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XI. *Gunshot Wound of Thigh near Poupart's Ligament, dividing (probably) the Femoral Artery; but little Bleeding at the Time; Secondary Hemorrhage on Sixth Day; Compression and Liquor Ferri Persulph. employed to arrest it without Success; Ligature of the External Iliac Artery; no Bleeding afterwards; Death from Exhaustion on Seventeenth Day subsequent to Operation; the Operation itself answered a Good Purpose, but the Patient never rallied from the Loss of Blood produced by Secondary Hemorrhage.* — James Brown, of the 3d Tennessee Mounted Infantry, was shot through the thigh, just below Poupart's ligament, at the battle of Chickamauga. The ball passed through the inner side of the thigh (right), obliquely from before backward, but did not implicate the bone. The man was taken to the field hospital, and the wound carefully examined; it was feared that the artery had been wounded, but as there was no bleeding of consequence at the time, the case was left to nature, and the only dressings consisted of lint and water. *No pulsation could be felt below the wound.* The patient did well for six days. While at stool on the sixth day, hemorrhage suddenly supervened, which the ward surgeon tried to arrest by injecting into the wound a solution of persulphate of iron, with the addition of compression, but without success.

The patient was put under the influence of chloroform, and the external iliac artery ligatured after the method directed by Sir A. Cooper.

The patient survived the operation seventeen days; the ligature came away on the fifteenth day. There were no symptoms of peritonitis; the collateral circulation was fully established in the limb, heat and sensation being quite normal. Still the patient never rallied from the loss of blood, and gradually sank from exhaustion.

After the operation the soft parts for some distance around the wound became discolored, and finally sloughed. The separation of these sloughs in the man's reduced condition seemed to have been the immediate cause of his death. The tissues around the wound had been greatly infiltrated with blood, and doubtless the persulphate of iron also.

Would it not have been better practice to have enlarged the wound at once, and applied a ligature upon the bleeding vessel? This question is asked by Dr. Clendenin, the reporter of the case.

Comments. — That the femoral artery was struck by the bullet in this case there can be no doubt, because no pulsation could be

felt in the vessels below the wound immediately after it was inflicted. That the injury of the artery was not in the nature of a contusion, is proved by the fact that a contused wound of the walls of a vessel so large as the femoral artery near its origin, does not completely arrest the flow of the blood through it immediately, although it may become compressed to considerable extent by blood extravasated between the sheath and the coats of the artery. Several hours would seem to be required for the production of complete occlusion from the operation of this cause; and several days would be required to close the artery at the place of injury, by constriction or stricture effected through the agency of the inflammatory process. That the wound of the vessel did not consist in a partial division of it is shown by the circumstance that the primary hemorrhage was not troublesome, for the external bleeding which is produced by the partial division of a large artery does not cease spontaneously until the subject faints, and is brought very low from loss of blood. Furthermore, that the wound sustained by the femoral artery consisted in a complete division of it is rendered probable by the circumstance that not unfrequently large arteries, when *severed* by gunshot projectiles, give issue to but little blood at the time of injury. The clinical facts upon which this statement is based will be more fully given in the sequel.

Spontaneous arrest of hemorrhage.

The hemorrhage which took place on the sixth day was, no doubt, hastened, in respect to its occurrence, by the movements on the part of the patient in going to stool. With regard to the plan of treatment required by the case, my views coincide with those entertained by Dr. Clendenin. I believe that when the hemorrhage occurred the wound should have been enlarged, and the bleeding vessel secured by both proximal and distal ligatures at the place of injury without delay.

This case also serves to illustrate some of the evils which may grow out of the employment of the persulphate of iron for the arrest of hemorrhage, when large arteries are wounded. In the first place, this styptic, even when assisted by pressure, failed to control the bleeding, in consequence of which the patient lost a much larger quantity of blood than he would have done if the bleeding vessel had been promptly tied. Indeed the hemorrhage was not permanently arrested until the external iliac artery was ligatured. Now, when we reflect that in this case the hemorrhage was very profuse, that it was unnecessarily protracted by the employment of persulphate of iron and

Bad consequences of the use of persulphate of iron and pressure.

pressure, which proved to be agents insufficient for its arrest, that the patient never rallied from the loss of blood, and that in the end his death was in reality produced by it, we may be led to think that his death should be charged to persulphate of iron. The fact that, notwithstanding his exhausted condition, he survived the operation of tying the artery for seventeen days, inclines us to believe that he would have made a good recovery if the wounded vessel had been promptly secured on the old plan. This truth should always be borne in mind when we are called on to treat profuse arterial hemorrhage, namely, that if we expect to save our patient, we have no time at our disposal to sacrifice in experimenting with insufficient agents. In the second place, the injection of the persulphate of iron into the wound changed the appearance of the parts so much as to render the performance of the best operation for the arrest of the bleeding difficult if not impossible. In the third place, the employment of persulphate of iron and pressure at the wound, induced sloughing of the parts in that neighborhood, which assisted not a little in destroying the patient's life.

Should not waste valuable time in trying insufficient agents.

The next case is a very interesting one, wherein the *femoral artery was divided by a minie ball* near the middle of the thigh, and the vessel was secured by ligature at an early period.

Case XII. *Gunshot Wound of Thigh near its Middle, severing the Femoral Artery; Vessel tied both proximally and distally at End of Twenty-four Hours; Secondary Hemorrhage Six Days after Injury; it was controlled by Pressure; Gangrene; Death on Eleventh Day; Autopsy; Femoral Vein also found to be ligated; Distal Ligature of Artery had separated; the Secondary Bleeding occurred from the Distal Orifice.* — Christopher Gross, private, Company K, 6th Pennsylvania Cavalry. Was wounded, May 30, 1864, near Mechanicsville, Va., by a minie ball, which entered the outer side of his left thigh, near its middle, and passing through anterior to the bone, made its exit at a point opposite, having divided the femoral artery in its course. It then passed through his right thigh, producing a flesh wound thereof. The patient laid in the woods for the next twenty-four hours, during which time hemorrhage occurred several times from the internal wound, which he partially controlled by pressure with his fingers. The next morning, May 31, his condition was discovered, and he was conveyed to the field hospital, where the femoral artery was ligated both at its proximal and distal ends. The operation consisted of an incision eight inches in length. At the lower end of the incision the sartorius muscle was divided. June 4. Five days afterwards he was admitted to Stanton U. S. General Hospital, with the limb very much swollen, œdematous, and presenting

dark patches of extravasated blood around the groin; pulse weak; countenance pale. Sunday, June 5. Hemorrhage occurred at the wound of operation, and was supposed to come from the distal end of the artery. It was controlled by persulph. ferri and ice. Only about four ounces of blood were lost. During the afternoon of the same day, hemorrhage again occurred, which was stopped by pressure on the femoral at the point of its passage over the pubis, and was continued by means of a weight. The same treatment was continued, which consisted of free stimulation and nutrients. The constitutional condition of the patient at this time was very low. Pulse feeble and quick, and great pallor of the surface. Wednesday morning, June 8. Owing to the sloughing condition from the pressure made by the weights, they were removed. About four o'clock of the same day, hemorrhage again occurred, which was arrested by digital pressure; the weights were again applied. He gradually sank and died from exhaustion, at five o'clock, A. M., June 9. *Autopsy* eight hours after death. Limb very much swollen. Muscles extensively infiltrated with pus, extending from the groin to the knee. The femoral artery was found to be severed in the track of the ball, about its middle. A ligature was found on the proximal portion about two inches from its end. *Another ligature was found in the wound, which had come away from the distal end. The distal portion of the artery was pervious. It was therefore obvious that the hemorrhage had taken place from it, on account of the premature separation of the ligature.* The ligature on the proximal end was still firm. The femoral vein was also found ligated. It had a separate thread upon it. For what purpose this ligature had been applied is unknown. The vein had not been divided nor even wounded by the projectile. The limb had begun to mortify prior to death.

Bad consequences of pressure.

All the viscera were normal.

Comments. — For the notes of this case the author is indebted to Acting Assistant Surgeon Charles H. Osborne, U. S. Army. The name of the operator is not known. The case is placed on record here not so much for the purpose of criticising the operation that was performed, as because it presents us with an experiment made on the living human body, whether by accident or by design it matters not for our present purpose, illustrating the consequences of tying the femoral vein. Viewed in this light the case presents very great interest. The hemorrhage from the distal aperture which occurred in this case appears to have been largely promoted by the ligature which had been applied to the femoral vein. Thus the vein being distended with blood below the place of ligation would present no inconsiderable obstacle to the passage of the blood through the capillary vessels from the ultimate branches of the arteries into the

Consequences of tying the femoral vein.

venous radicles, and thus the blood would naturally acquire an increased tendency to flow backward in the artery, and to escape from the distal aperture in the femoral artery into the wound.

Again, the ligation of the vein probably exerted considerable influence in the production of the wet gangrene, for it appeared at so late a period in the history of the case, that it is not probable that mortification would have occurred, if a ligature had not been applied to the vein. He died on the eleventh day, and gangrene did not appear till a short time before death. Its effect in causing gangrene.

The primary hemorrhage in this case did not prove immediately fatal, although a period of twenty-four hours elapsed after the patient was wounded before he received surgical assistance. But it is probable that the loss of blood which occurred during this period contributed not a little to hasten the fatal result, since when he was brought to the general hospital, he was so pale and feeble from loss of blood that his recovery seemed to be almost hopeless. The highly swollen œdematous and suggillated condition of the limb, at this time, would have rendered the performance of any additional surgical operation for the arrest of hemorrhage difficult if not impossible. Amputation was entirely out of the question.

In the next case, which was an instance wherein the *femoral artery was severed by a small-arms projectile* near the middle of the thigh, the primary hemorrhage was very profuse, and, although the vessel was promptly tied on the field of battle, the loss of blood had been so great as to occasion death on the next day. The history of said case was contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XIII. *Gunshot Wound of Thigh near its Middle, involving the Femoral Artery; Hemorrhage very profuse; Vessel ligated on the Spot; but the Patient had lost so much Blood that he died Twenty-eight Hours afterwards; the Autopsy showed that the Femoral Artery was completely divided, and that the Femoral Vein was not injured.* — In a skirmish between a squadron of the 10th Tennessee Mounted Infantry, and Wheeler's Cavalry, October 1864, James O'Neal received a wound in the right thigh, near the middle, on its inner aspect — bone not implicated. Profuse arterial hemorrhage immediately ensued. The soldier fainted before he could be taken from his horse. The regimental surgeon was present, and, assisted by the assistant surgeon, immediately proceeded to ligate the femoral artery. The operation was well done. The patient was then carried on a stretcher five miles to Lavergne Station, about twelve miles from Nashville, to which place he was brought on the following day by railway.

The loss of blood was so great that the patient died twenty-eight

hours after the ligature was applied. Death resulted from the loss of blood. An examination of the wound made after the patient's death, disclosed the fact that the *femoral artery* was *completely divided;* the *vein* was to all appearance *uninjured.*

In the following case of gunshot wound of the femoral artery, the primary hemorrhage proved quickly fatal. The account of it was also contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XIV. *Gunshot Wound of Femoral Artery near Middle of Thigh; Hemorrhage very profuse, and Death occurred before the Patient could be transported to the Field Hospital, a Distance of about One Mile.* — The following case will serve to illustrate a large class of cases which every military surgeon has met with on the battle-field.

Sergeant French, 4th U. S. Cavalry, was struck by a ball on the inner side of the left thigh near its middle, while the regiment was in the act of forming a line. The bone was not injured. The regimental surgeon was about two hundred yards from the man at the time he was wounded, and hastened to his assistance. The wound was bleeding most profusely. The blood was arterial and flowed *per saltum.* When taken from his horse he fainted. The tourniquet was applied, and the bleeding stanched.

The line was falling back, and the wounded had to be hurriedly removed to the rear. The man was ordered to the field hospital, about one mile distant. An assistant surgeon superintended the transfer, but the patient died before reaching the hospital.

The surgeon had neither lights nor fire, consequently ligation of the artery on the field of battle was wholly impossible.

Dr. Baylor's case.

But Dr. J. C. Baylor, of Norfolk, Va., has published a case in which the *femoral artery was completely divided by a minie ball, without consecutive hemorrhage.*

Case XV. J. W. Dinguid, lieutenant, artillery service, wounded by minie ball on the 1st of June, 1864. *Femoral artery severed in its lower third; no consecutive hemorrhage;* died June 15, fourteen days after injury. *Autopsy.* — No effort at repair; gangrene of foot had commenced; the wound in thigh a sloughing mass.[1]

Summary of five cases in which the femoral artery was severed by gunshot projectiles.

Comments. — We have thus related five cases in which it is believed that the femoral artery was severed by gunshot projectiles. In one case that vessel was injured near Poupart's ligament, or in the first part of its course; in three cases the wound was inflicted near the middle of

[1] Vide *American Journal Medical Sciences,* Oct. 1865, p. 254.

the thigh; and in one case the artery was divided in its lower third.

In two cases the *primary hemorrhage* was either very slight or entirely absent. In one case it was considerable in quantity, and in two cases it was very profuse, and caused the death of the patients, although surgical assistance was near at hand at the time the wounds were inflicted.

In two cases *secondary hemorrhage* occurred. In one of them it was very profuse, and induced death by exhaustion. In the other it occurred from the distal orifice, and appeared to be connected with a ligature which had been applied to the femoral vein.

In two cases the foot belonging to the injured limb was attacked with *gangrene*. In one of them the artery was severed in its lower third, and in the other near the middle of the thigh, and was complicated with ligation of the femoral vein.

Every one of these five cases terminated fatally. Two died of primary hemorrhage, one of exhaustion following secondary hemorrhage, one of gangrene, and one of secondary hemorrhage and gangrene. All of them died.

One of them died before he could be transported to the field hospital, a distance of about one mile, another in twenty-eight hours, another on the eleventh day, another in fourteen days, and the remaining one on the twenty-third day after the wound was inflicted. Duration of the several cases.

We will next relate three cases in which it is believed that the *popliteal artery was completely divided* by a small-arms projectile. We shall also make brief mention of a fourth case belonging to the same category. The following case has been contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers: —

Case XVI. *Gunshot Wound of Popliteal Artery; Hemorrhage at first profuse, but it ceased spontaneously; Consecutive Gangrene of Foot and Leg; Amputation of Thigh on Thirteenth Day after Injury; Recovery.* — Samuel C. McCreary, aged twenty-four years, private 100th Pennsylvania Volunteers, was wounded at the battle of Chantilly, September 1, 1862, through the popliteal space of the right inferior extremity. The orifice of entrance of the ball was about three inches above the point of insertion of the biceps flexor, the ball passing through that muscle immediately behind the os femoris, and emerging through the hamstring muscles on the inside, chipping out a small fragment from the inner condyle.

He lost a good deal of blood while on the field, but the bleeding ceased of itself. He was carried in an exhausted state to an old shanty

in the vicinity of the battle-ground, where he remained three days without food, excepting one army biscuit. On the fourth day he was transferred to hospital (Baptist Church) at Alexandria, Va. When admitted to hospital, the patient was in a very feeble condition, and had an exsanguined appearance; pulsation could not be detected in either branch of the popliteal artery, and the temperature of the limb was very perceptibly lower than that of the well limb. Every means that could be devised was used to preserve the temperature of the limb, but without avail; the toes, at first of a purplish hue, became black; gangrene rapidly extended over the foot and ankle, and thence up the leg. Amputation four inches above the knee-joint was performed by the flap operation on the 13th of September, while the patient was under the influence of chloroform.

For nearly three weeks after the operation, the patient's life was almost beyond the hope of recovery; there was almost total anorexia; and large bed sores, which formed about the sacrum, served to increase the suffering and to complicate the case. The patient, however, with the aid of stimulants, tonics, and nutrients, together with proper attendance, recovered slowly, and left the hospital on the fourth day of December, in the care of his father. Stump nearly healed.

About one year after the operation, the point or centre of the stump inflamed, and two small pieces of bone were thrown off. Patient did not have neuralgia in the stump. Is now, January 8th, 1866, in good health.

Dr. Clendenin's case of gunshot wound of popliteal artery.

The above is the almost exact prototype of a case of wound of the popliteal artery, which occurred at the battle of Chickamauga, with similar treatment and results.

It is believed that in the foregoing case of gunshot wound of the popliteal space, inflicted in the battle of Chantilly, the popliteal artery was severed by the projectile, because the hemorrhage, which at first was profuse, after a time ceased spontaneously — a circumstance that in all probability would not have come to pass, if the vessel had been only partially divided.

The same remark doubtless holds true with regard to the case of wound of the popliteal artery, which is mentioned as having occurred at the battle of Chickamauga.

These then may be fairly considered as cases of gunshot wound, involving the popliteal artery and severing it, which were followed by gangrene of the foot and leg, and on being treated by amputation of the thigh made good recoveries.

CASE XVII. *Gunshot Wound completely dividing the Popliteal Artery; Hemorrhage ceased spontaneously; followed in Four Days by Gangrene of the Foot and Leg; Amputation of the Thigh, and Death by Exhaustion on*

the Fifth Day afterwards. — Private James H. Dutcher, Company M, 2d N. Y. Heavy Artillery, aged 24, was admitted to the Stanton U. S. Army General Hospital, June 4, 1864, from the field. He had been wounded four days previously, May 31, in action near Cold Harbor, Va., by a musket-ball (conical), which passed through the left leg from before backwards, just below the knee, and involved the track of the popliteal artery near its termination. He was very feeble, and the leg was gangrenous. He was placed on supporting treatment with a view to prepare him for successful amputation if possible.

June 5. — Leg and foot greatly swelled, discolored dark-brown, presenting a gangrenous appearance, and emitting an offensive gangrenous odor. There are several large blebs on the leg which are filled with a brownish-colored serum. Thigh much swelled and hot to feel. It presents an ecchymosed appearance throughout the greater part of its surface. The swelling extends up to the groin. His countenance is pale and anxious, his pulse is frequent and weak, he is much debilitated, and expresses a strong desire to have the limb amputated. His tongue is coated, and he has little or no desire for food. So far as the gangrene is concerned, no line of separation is yet apparent.

Sulphuric ether was administered as an anæsthetic, and the thigh amputated by the author, by the flap method, high up in its upper third. The femur was sawed off three fourths of an inch below the trochanter minor. An assistant compressed the femoral artery against the pubes with his fingers. After forming the anterior flap, both the superficial femoral and profunda arteries were secured by ligature before the posterior flap was cut out. The operation presented no unusual difficulty. It was, however, attended with the loss of a considerable quantity of blood, occasioned mainly by the abnormal vascularity of the swollen and inflamed tissues through which the operation had to be performed.

The shock of the operation was very great. Reaction was established with considerable difficulty, and was not complete till the following day. Ordered him to have a nourishing diet, together with ferri et potass. tart. and stimulants such as porter, ale, or wine.

The autopsy of the amputated member showed that *the popliteal artery was completely severed by the bullet, at its lower extremity, near where it terminates in the anterior and posterior tibials.* This lesion of the popliteal artery had occasioned the gangrene of the leg.

June 6. — He is feeble, pale, and anæmic.

June 7. — Condition unchanged; pulse about ninety, and weak.

June 8. — No improvement; stump in a sloughing condition. He died at eleven o'clock, P. M., apparently of exhaustion. He had obstinate vomiting with hiccough on the last day of his life.

This patient's death was hastened by the fact that his system was contaminated with the decomposing fluids which were imparted

to it from his gangrenous leg. The truth is, that his injured limb should have been amputated during the primary period, and after that had passed away it should have been excised as soon as the spots of commencing gangrene made their appearance. No time should have been allowed for his system to become poisoned by the mortified leg.

Septæmia from gangrenous leg.

Case XVIII. *Gunshot Wound of Left Knee-joint, severing the Popliteal Artery; Death Thirteen Days afterwards.* — W. D. Thompson, private, 5th Cavalry, Company E, aged 40 years. Gunshot wound (minie) of left knee-joint, ball entering outer portion of popliteal space, traversing inner condyle, and emerging at inner side of joint. *Popliteal artery completely severed; no consecutive hemorrhage;* no effort at repair in wound. Wounded May 5th, died May 18th, thirteen days after.[1] Case reported by Dr. J. C. Baylor, of Norfolk, Va.

Comments. — We have thus presented some account of four cases of gunshot wound of the popliteal artery, in which that vessel was severed by the projectile. In all of them the bleeding ceased spontaneously. In three of them consecutive gangrene of the foot and leg occurred. In the remaining case it is not stated whether mortification took place. Now, proceeding on the hypothesis that the last case was not gangrenous, it certainly affords a very large proportion in which mortification occurred (75 per cent.). For the occurrence of this high ratio of gangrene in cases belonging to this category, there is a good reason founded on the anatomical structure of the neighboring parts. The popliteal artery itself *having been severed by the projectile*, is no longer able to transmit the blood to the parts below the place of injury. If these parts should continue to be properly nourished, the blood for that purpose must be derived through the collateral channels. Now, in such cases, the collateral circulation must be established through the articular branches at the knee, and they are so small in size as to afford, at best, only very inadequate facilities for establishing the collateral circulation. But, in cases of gunshot wounds involving the popliteal space and the knee-joint, even these scanty facilities are still further diminished; for the inflammation which, under such circumstances, is kindled in the neighboring parts, produces swelling that compresses the blood-vessels, and thus tends to diminish the flow of the blood through the anastomosing branches of the popliteal artery.

Summary from four popliteal artery cases.

Of these four cases two died, and two recovered. Both patients

[1] Vide *American Journal Medical Sciences*, Oct. 1865, p. 254.

who recovered underwent amputation of the thigh. In one of the fatal cases amputation was not successful, because it was performed at too late a period in the progress of the case.

Two died. Two saved by amputation.

Gangrene follows gunshot wounds of the popliteal artery with so much certainty, that I am inclined to believe primary amputation should be practiced in such cases, because it is the procedure which is most likely to save the patient's life.

It is next in order to relate two cases in which the *posterior tibial artery was severed* by a cylindro-conoidal musket-ball. In one of them the fibula was also fractured, but in the other the bone was not injured. In both cases the wound of the artery was the principal injury, and in both also traumatic gangrene occurred. In both instances the primary hemorrhage ceased spontaneously.

Gunshot wounds of posterior tibial artery followed by gangrene.

Case XIX. *Gunshot Wound through Calf of Right Leg, with Division of Posterior Tibial Artery; Consecutive Gangrene of Leg commencing on the Seventh Day; Amputation of Limb at Lower Third of Thigh; Death Ten Days afterwards from Pyæmia; Osteo-myelitis of Stump-bone, Pyarthrosis of Hip-joint; Thrombosis of both the Deep and the Superficial Femoral Veins, and Lobular Pneumonia found at the Autopsy.* — Private Conrad Kogel, Company D, 15th N. Y. Heavy Artillery, aged 39 years, was admitted to the Stanton U. S. Army General Hospital, June 4th, 1864. He stated that he was wounded at Mechanicsville, May 30, by a minie ball, which passed nearly transversely through the calf of his right leg, from without inward, and somewhat upward.

At the time of admission his leg was very much swelled and inflamed up to the knee. No tibial pulse could be felt at the ankle. He also had much constitutional disturbance, and was very restless. The ice dressing was applied to his leg, and he was placed upon the use of nutrients, tonics, and stimulants.

June 5. — He was no better.

June 6. — His leg was still more swollen, and beginning to mortify in spots. His constitutional condition also was worse, and he had irritative fever of a low type. He was etherized, and the gangrenous limb was amputated at the lower third of the thigh by Acting Assistant Surgeon Charles H. Osborne, U. S. A., by the circular method. The shock was moderate, and he reacted promptly. The stump was left open with a view to facilitate the outflow of the purulent discharge. He was directed to take the syrup ferri et potass. tart. as a tonic. Examination of the amputated member showed that the posterior tibial artery had been divided by the bullet.

The patient experienced much relief from the operation, and his gen-

eral condition continued better until June 10, when the flaps began to slough.

He then sank into a typhoid condition, his tongue became dry and brown, and he got diarrhœa. Pulv. opii et bismuthii was prescribed for his diarrhœa.

June 15 (evening). — He had a pyæmic chill, after which he sweat profusely. He also complained of pain in his right wrist, which was swelled and tender (pyarthrosis). Ordered quiniæ sulph. in full doses, and free stimulation with alcoholics.

June 16. — He had two rigors. The sweats continued. His countenance had become sallow. He was delirious. He sank and died in the evening.

Autopsy eighteen hours after death: cadaver emaciated; right arm swelled; right wrist ecchymosed; stump sloughy; end of stump-bone denuded of periosteum; *marrow at end of stump-bone dark-green in color and gangrenous; above this part the marrow was red in color and carnified;* the cancellous structure of the head of the stump-bone, and indeed of the whole epiphysis, was congested (hyperæmic), especially in spots; the *hip-joint was full of thin, whey-like, purulent matter;* the *caput femoris* was *denuded of cartilage*, but the acetabulum was not; *both the superficial and the deep (profunda) femoral veins were filled with coagulated blood (thrombosed); the thrombosis terminated at the commencement of the external iliac vein.*

Patches of lobular pneumonia, of recent occurrence and red in color, were found in the lower lobe of both lungs. The pericardium contained a moderate amount of serum, having a pale, reddish-yellow color. The right ventricle contained a large coagulum, and the left ventricle a small one. *The spleen was somewhat enlarged and very soft.* Liver normal. Left kidney normal. Right kidney a little larger than the left and softened.

Comments. — This case possesses very great interest on account of the pathological lesions which followed the wounding of the posterior tibial artery. In the first place there was consecutive gangrene of the foot and leg, and the thigh was amputated because of it. In the second place *acute osteo-myelitis* occurred in the stump-bone. In the third place *pyarthrosis of the hip and wrist* supervened. In the fourth place the symptoms of *pyæmia* were developed, of which he died. At the *autopsy* both the deep and the superficial *femoral veins* were found to be *thrombosed*, or filled with coagulated blood, patches of *lobular pneumonia* of recent occurrence were found in the lower lobe of each lung, the *spleen* was somewhat *enlarged* and *very soft*, and the pericardium contained a moderate amount of serum, having a light reddish-yellow color.

Thus, we have clearly placed before us the consequences of a gunshot flesh-wound of the leg, severing the posterior tibial artery, namely, traumatic gangrene, together with the pathological conditions which followed amputation, performed on account of the gangrene, namely, osteo-myelitis of the stump, pyarthrosis of the hip and wrist, thrombosis of the thigh-veins, and various lesions of the viscera, which are connected with the pyæmic process.

Case XX. *Gunshot Wound of Left Leg, with Division of Posterior Tibial Artery in Upper Part of its Course, and Fracture of Fibula; Consecutive Gangrene of Leg; Death on the Tenth Day after the Wound was inflicted.* — Lieut.-col. W. G. Delaney, a prisoner of war, was admitted to the Stanton U. S. Army General Hospital, September 25, 1863, having been wounded and captured on the 23d, two days previously. A conical musket-ball penetrated his left leg, on its outer side, about two inches below the head of the fibula, and after fracturing that bone with comminution, passed through the limb in such a way as to cross the track of the posterior tibial artery a short distance below its origin. It is stated that there was considerable hemorrhage immediately after the wound was inflicted, but it ceased spontaneously, and did not return.

When admitted to hospital, the attending surgeon reports that the patient had considerable fever of an irritative type, that there was some œdematous swelling of the leg below the wound, and that no pulsation could be detected in the posterior tibial artery at the ankle. Afterwards the swelling and œdema of the leg increased, the limb became gangrenous, and he died, October 2d. When death took place his leg was swelled to twice its natural size, and presented a dark-brown mottled appearance. No line of separation was formed. After the symptoms of gangrene revealed themselves, his general condition was not such, at any time, as to warrant the performance of amputation.

The *autopsy* showed that the fibula had been fractured with considerable comminution, and that *the posterior tibial artery had been completely divided by the bullet, about an inch below its origin at the bifurcation of the popliteal.*

Comments. — Gunshot wounds of the middle and upper thirds of the leg, which, at the same time, sever the posterior tibial artery, almost always produce gangrene of the parts situated below the place of injury. The reasons for this occurrence are twofold. In the first place by the division of the artery the parts are deprived of the supply of blood which they have been accustomed to derive from that source. In the second place gunshot wounds passing through the fleshy portion of the leg are usually accompanied by a great deal

Gunshot wounds of middle and upper thirds of leg, which sever the posterior tibial artery generally followed by gangrene.

of inflammatory swelling, and this is more especially the case if, at the same time, one or more of the bones be injured by the projectile. Now this inflammatory swelling is produced in the parts which are situated within the deep fascia of the leg, as well as in those which are situated on the outside of it. The effect of the tumefaction beneath the fascia is to prevent the establishment of the collateral circulation, and, as it were, to strangle the circulation of the blood in the small vessels. The consequence is that the parts situated below the place of injury do not receive sufficient blood to keep them alive, and then they fall into a state of *dry* gangrene of necessity.

Gunshot wounds of the leg which sever the posterior tibial artery, the bone being at the same time injured by the projectile, are so certain to be followed by gangrene, that in my opinion *primary* amputation ought always to be practiced in such cases. But if from any cause the primary period has been allowed to pass away without operating, the excision of the limb should not be delayed at all after the spots of commencing gangrene have made their appearance.

Gunshot wounds dividing axillary artery.

We shall now proceed to relate three cases in which the *axillary artery was probably severed by small-arms projectiles.* We shall also refer to another important case belonging to the same category. Of these four instances of gunshot division of the axillary artery, three occurred during our War of the Rebellion.

Case XXI. *Axillary Artery wounded by a Rifle-ball (conical); Hemorrhage ceased spontaneously; Recovery without Suppuration;* reported by Dr. James M. Holloway, in the "American Journal of Medical Sciences," October 1865, pp. 352, 353. — Claude H. Dinkins, corporal Light Artillery, aged 31 years, merchant, health good, wounded July 18, 1864, near Petersburg, by a sharp-shooter. Gunshot wound (small minie ball, which, after striking him, wounded his companion) through the left shoulder; ball entering behind on a line with and about two inches to the right of the axillary crease, made its exit in front about one inch above the anterior angle of the axilla. A note from Dr. W. M. Nash, who saw the patient in camp a short time after receipt of wound, is as follows: "The axillary nerves are seriously injured, and indeed the artery does not seem to have escaped, though no hemorrhage has occurred; the impulse in the radial artery is very slight. July 20th, near Petersburg."

July 23. — I saw the patient for the first time this morning; he states that he has felt the pulse at the wrist occasionally, and that at

such times he experiences a sense of fullness, as if the arm was filling with blood. He states also that Dr. Palmer, of Florida, has examined him frequently since admission, and thought he could detect pulsation at the wrist. Sensation perfect in hand and arm, excepting numbness in the thumb. *The wounds of entrance and exit are closed by clots; no discharge;* no evidence of inflammation; complains of occasional pain in the hand. Removed to a tent and ordered moist dressings and rest in recumbent posture.

July 24. — Rested well under influence of morphia. *I can discover no pulse at the wrist, nor at any point along the course of the vessel below the seat of injury.* Arm cool, pain not distressing; *wound still dry, and clots undisturbed.* Dr. J. B. Gaston, of Alabama, thinks he can discover a feeble pulse at the wrist.

July 25. — Suffering from nervous twitchings in arm and shoulder, which he mitigates by bathing the parts in cold water; *clots dissolving; no sign of pus.*

August 4. — No change of interest has occurred since last note, the case progressing favorably; *no pulse at wrist, nor discharge of pus from the wounds, which are now closed by scab;* suffers at times with severe pain throughout the limb, or, as he describes it, "along the course of the nerves."

August 13. — Furloughed, to proceed by easy stages to his home. Has not experienced an unpleasant symptom, excepting pain in the limb. The wound has healed throughout its whole tract by McCartney's "modeling process," except at the orifice of exit, where, on the 12th, a small quantity (only a few drops) of pus formed after the scab had been removed through carelessness of the nurse. *Pulsation below the seat of injury was not felt by myself at any time during the progress of the case, though repeated examinations were made.*

In the following March I heard by letter that Mr. Dinkins was enjoying excellent health, and that the wounds were entirely healed. Strength and motion of the limb somewhat impaired. The long-continued absence of pulsation in the main branches below the seat of injury in this case, forms, in my experience, an exception to the general rule.

Comments. — What was the nature of the injury that was inflicted upon the axillary artery in this case? We can state with confidence, at least, that it did not consist of partial division of said vessel; for, if such a wound had been inflicted, the hemorrhage would have been very profuse, and followed either by the death of the patient, or the formation of a traumatic aneurism, unless the artery had been promptly tied. Did the wound of the vessel consist of a contusion of its walls from being struck by the projectile on the one hand, or was it completely divided on the other? It

appears to me certain that either the one or the other of these two forms of vascular injury was sustained by the axillary artery in this case, but which of them it is impossible to say with confidence, since the published report is not sufficiently explicit, and even contains discrepant statements upon the points in the clinical history which would settle the question.

Case XXII. *Gunshot Wound of the Axillary Artery (right), and Axillary Plexus of Nerves; but Little Hemorrhage; Recovery;* reported by Baron Larrey.— General Dulong received a gunshot wound in the right axilla in the Polish campaign of 1807. The ball had passed through the tendon of the pectoral muscle and the plexus of nerves, grazing the shoulder-joint. *Although there was scarcely any hemorrhage, there was good reason to believe that the axillary artery had been divided.* Some years subsequently this officer called upon me for my advice. I then learned that, immediately upon the receipt of the wound, the extremity had been stricken with a paralytic torpor and a sense of the most distressing coldness, and that no pulse could be felt at the wrist. It had been unwisely determined to try to save the limb. The consequence was, that the hand and arm remained quite paralyzed, and became so atrophied as to resemble a part of a mummy rather than a part of a living man. I recommended him to submit to amputation; but he would not. His infirmities increasing, he committed suicide.

In this case of complete division of the axillary artery by a gunshot projectile, it should be observed that there was scarcely any hemorrhage. In the case narrated last before it, the hemorrhage also was slight, for *the orifices of entrance and exit were plugged up with coagulated blood*, which probably would not have occurred if the artery had been only bruised by the ball. I am therefore inclined to believe, that in said case (that of Dinkins, No. XXI.), the axillary artery was completely divided by the ball.

Case XXIII. *Axillary Artery severed by a Gunshot Projectile; Hemorrhage not troublesome; Consecutive Gangrene of the Arm; Death by Exhaustion Twenty-five Days after the Injury; the Autopsy verified the Diagnosis.*— Private T. H. Hudson, a prisoner of war, aged 21, was admitted to the Stanton U. S. Army General Hospital, May 18, 1864. He had received two wounds from fire-arms at Spottsylvania Court-house, Va., May 11th. One ball entered his right hip near the sacrum, and made its exit in front near the right groin. The other ball penetrated the left shoulder from behind, and escaped in front a little way below the clavicle.

On admission to hospital the patient's general condition was good, and his wounds looked well. It was observed that he had no radial

pulse on left side. Simple dressings were applied to the wound, and he was allowed a nourishing diet.

May 22. — The wounds appear to be doing well, but the left arm has become much swelled and dark in color. No brachial nor radial pulse can be detected in it.

May 28. — The gangrene of the arm is still progressing. The mortified tissues of the fore-arm are exulcerating. Prescribed tinct. ferri muriat. gtt. xx. every four hours, together with spts. frumenti f. ʒvi. per diem.

June 1. — The gangrene is limited at middle of arm. The wounds look well, but still he is obviously failing. He is much emaciated, his tongue is dry, his appetite poor, and he has some diarrhœa.

He continued to sink, and died June 6th, of exhaustion.

At the *autopsy the axillary artery was found completely divided by the bullet, and the ends had retracted from each other.* Both the proximal and distal ends of the severed artery were securely plugged up. They were separated from each other by a distance of about two inches. *The axillary vein and the brachial plexus of nerves were not wounded. The hemorrhage did not prove troublesome even when the wound was inflicted,* and no bleeding whatever occurred subsequent to his admission to general hospital.

Comments. — Although this patient's general condition did not seem to justify us in amputating his arm at any time subsequent to the occurrence of the gangrene, because it was so low, still, on reviewing the case now, I am inclined to think that the operation might have improved his chance of recovery somewhat, especially if it had been performed as soon as the gangrene appeared. While making our criticisms upon the treatment of this case, we should, however, bear in mind that *almost every case of secondary amputation performed in Stanton Hospital during the months of May and June,* 1864, *proved fatal,* and it is highly probable that this fact exerted no small degree of influence for inducing us to postpone the amputation of this man's gangrenous arm.

In this case, the hemorrhage did not prove troublesome even when the wound was inflicted, and it did not return afterwards. It should be observed in this connection that, at the autopsy, the artery was ascertained to have been *severed* by the bullet, and the ends of the divided vessel were found retracted and separated from each other to a distance of about two inches. I have witnessed the same phenomenon of retraction and separation in another case, wherein the axillary artery had been severed by a carbine shot, and which will be related in the chapter on traumatic aneurism.[1]

[1] Vide Case of Captain Jordan, No. XXXVII.

In the case last mentioned, the primary hemorrhage also did not prove troublesome, and quickly ceased without assistance. But this immunity from destructive primary hemorrhage, in cases of gunshot wounds which penetrate the calibre of the axillary artery, does not obtain unless the vessel happens to be completely divided by the bullet. If it be only partially divided, the bleeding will be very profuse, and will be likely to prove fatal unless it is arrested by surgical assistance, or by some fortuitous circumstance. In Case No. VIII., that of Wm. Hall, the axillary artery was divided about half-way through by the projectile. The hemorrhage was excessive, and it is said that he lost a bucketful of blood before he reached the hospital. On his admission there he was in a state of syncope, and could not speak. It should also be remembered that, in this case, the track of the wound in the parts exterior to the vessel was, to a certain extent, plugged up with pieces of clothing which had been carried forward into the wound by the bullet. It is not difficult to conceive what would have happened to this patient if no obstruction to the escape of blood had existed in any part of the wound. The contrast between the amount of blood which is lost by hemorrhage in cases of partial division of the axillary artery by gunshot projectiles, on the one hand, and complete division of that vessel by the same means on the other, is very striking. Of the four cases of gunshot wounds which severed the axillary artery, that we have just related or referred to, two exhibited scarcely any bleeding, in one the hemorrage did not prove troublesome, and in the other it ceased spontaneously after a single though copious gush of blood. We therefore say that, notwithstanding the large size of the axillary artery, and its nearness to the great centre of the circulation in respect to situation, the primary hemorrhage from gunshot wounds which divide it completely, generally does not prove fatal, and but seldom proves even troublesome. As already stated, if this vessel is but partly divided by the ball, the primary hemorrhage will either be fatal or place the patient's life in great peril.

Primary hemorrhage generally does not prove fatal where the axillary is completely divided.

The case last related also appears to me interesting in another respect, namely, the consecutive gangrene of the fore-arm and arm. If the vessel had been only bruised, I can readily perceive how embolism might have occurred in the extremity, and might have also produced mortification of it. But the artery was completely divided by the projectile, and its ends were widely separated from each other. The wound gave but little trouble. The vascular

connections at the shoulder and axilla between the subclavian and axillary arteries above, and the brachial artery below, are very abundant and intimate, and generally permit the establishment of the collateral circulation with great readiness. Now, in this case, when the axillary artery was severed, and the supply of blood to the extremity through that tube was suddenly stopped, I cannot perceive any good reason why the collateral circulation did not send forward a sufficient supply of blood to the extremity, at least, to maintain its vitality, and to prevent it from becoming gangrenous.

Summary of four cases in which the axillary artery was severed by gunshot projectiles.

Of the four cases wherein the axillary artery was divided by gunshot projectiles, that have been either related or alluded to, two recovered, and two died. In one case the fatal result was produced by consecutive gangrene, and in the other a traumatic aneurism occurred which ultimately destroyed the patient. In both instances of recovery no operative procedure was required. In all of them the primary hemorrhage ceased spontaneously.

Gunshot wounds dividing the brachial artery.

We shall next relate three cases in which the *brachial artery was severed by small-arms missiles.* All of them occurred in the late War of the Rebellion. The following case was contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XXIV. *Gunshot Wound of Arm severing Brachial Artery and fracturing Humerus; at first Hemorrhage was profuse, but soon it ceased spontaneously; Amputation; Recovery.* — Sergeant Trimble, aged 21, Company A, 3d Kentucky Volunteers, was wounded (by a minie ball) on the picket line near Dallas, Ga., June 15, 1864. The ball struck the left arm near the junction of the upper with the middle third, severing completely the artery, and shattering the humerus for four inches; for a moment or two hemorrhage was profuse, but it ceased spontaneously. In consultation it was decided to amputate the arm, which was performed at once (ant. post. flap.), *i. e.*, about four hours after the wound was received, about two inches below the head of the humerus. The patient was doing well next day, but was weak from the loss of blood. In the afternoon orders came for a hurried move of the hospital; the patient was hauled fifteen miles to Acworth, Ga. The stump had not been dressed for two days and a half, and when the dressings were removed the stump was found to be full of maggots. The flaps were adherent at some points anteriorly. The stump was finally cleaned; the patient was very feeble, and had no appetite. Prescribed whiskey with tinct. ferri chloridi. On the eighth day after the operation the patient was transferred to Chattanooga, and thence to Nashville, by railroad. While in hospital in Nashville, gangrene attacked the stump,

the patient became very much emaciated, but he ultimately recovered, and six months afterwards he was in the enjoyment of good health.

The next example was also contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XXV. *Gunshot Wound of Right Arm severing the Brachial Artery; no Hemorrhage except a slight Capillary Oozing; Recovery.* — John Brenan, Major of the 3d Kentucky Volunteers, aged 26, was wounded on the 27th of June, 1864, at Kenesaw Mountain, Ga. The ball (conical) passed through the anterior and inner aspect of the right arm, and directly across the course of the brachial artery. When he was brought to the field hospital there was no perceptible pulsation at the wrist. Sensation and motion were impaired. There had been no hemorrhage excepting slight capillary oozing. The pulsation of the artery could not be detected by passing the finger into the wound. The shock was very great, with tendency to syncope. The ordinary lint and water dressings were applied, and precautions taken to preserve the temperature of the wounded extremity. Specific directions were given to a nurse to be on the *look-out* for hemorrhage, and to compress the artery above the wound in case it occurred. But no bleeding ever took place. The temperature of the hand remained for some time very perceptibly lower than normal. For more than a month pulsation in the radial artery could not be felt at all, but it gradually became more and more appreciable.

Six months after the infliction of the wound I met the major, and on examination found the volume of the pulse of the wounded arm much increased, but it was not equal to that of the other arm, and partial paralysis continued; but the sensation and uses of the hand and forearm were improving. General health good; wound entirely healed.

Case XXVI. *Secondary Hemorrhage from the Brachial Artery, which had been severed by a Musket-ball Eighteen Days previously; arrested by the Application of Ligatures to both Ends of the Artery at the Seat of Injury; Death Thirty-nine Days afterwards from Pyæmic Pneumonia; Visceral Abscesses in Lungs and Liver found at the Autopsy.* — Private Warren J. Beverley, Company C, 17th Maine Volunteers, aged 27 years, was admitted to the Stanton U. S. Army General Hospital, May 23, 1864, on account of secondary hemorrhage from a gunshot wound of his right arm, with which he had been attacked in the streets of Washington while on his way homeward on furlough. He stated that he was wounded in the battle of the Wilderness, May 5th. A musket-ball penetrated his right arm just above the flexure of the elbow, and passing behind the biceps muscle, escaped on the inner side of the limb. Pressure was applied at the seat of the injury, and it arrested the bleeding.

On the 24th, however, the hemorrhage returned in the evening, and it was then discovered that the flow of blood proceeded from the brachial artery. It was then resolved to tie the artery at the place of injury, which was accomplished without much difficulty by making an incision about six inches in length along the inner border of the biceps muscle. The brachial artery was found completely divided by the projectile. Both the proximal and the distal ends of it were then secured by ligature. He lost in all about sixteen ounces of blood. The hemorrhage did not return after the operation, which was performed by Assistant Surgeon G. A. Mursick, U. S. Volunteers.

May 26.— A slight recurrent radial pulse can now be felt at the wrist.

June 3. — Fore-arm has become swollen; an abscess has formed in the wrist; incised it.

June 4. — An abscess has formed in the end of the middle and ring fingers, respectively; incised them.

June 16. — The wound of operation has healed, but purulent matter has burrowed among the muscles of the fore-arm. An incision about six inches long was therefore made on the outer side of the fore-arm for the purpose of discharging the imprisoned matter and preventing further burrowing.

June 25. — Suppuration in the fore-arm profuse, and his strength is also failing. His appetite is poor, and he has had diarrhœa with black watery evacuations.

June 30. — He has pyæmia.

July 2. — He died of pyæmic pneumonia.

The *autopsy* showed the right lung to be inflamed, and likewise the seat of several superficial abscesses. The liver was enlarged, pale-yellow in color, softened, and contained an abscess about the size of an almond. The spleen was somewhat softer than natural. The kidneys were one fourth larger than the normal size, mottled, and very pale in color. Their cortical substance was one third thicker than it should be, and was slightly granular. The post-mortem urine found in the bladder contained albumen.

Comments. — In this case, pressure applied at the seat of the injury arrested the secondary bleeding for the time being, but failed to control it permanently. On the next day the hemorrhage returned in the evening. No further time was lost in fruitless attempts to cure the tendency on the part of the brachial artery to bleed, by pressure. The vessel was promptly secured by ligature at the place of injury. Both the proximal and distal ends of the divided artery were tied. The hemorrhage was immediately arrested, and afterwards did not return. The operation proved successful in arresting the hemorrhage permanently, although the patient died thirty-nine days after its performance of pyæmia, or

as the record states, of pyæmic pneumonia. On making an autopsy, visceral abscesses were found in the lungs and liver, the spleen was discovered to be softened, the kidneys enlarged, mottled, pale, and somewhat granular, and the post-mortem urine was found to contain albumen, on testing it with heat and nitric acid.

Summary of three cases in which the brachial artery was severed by gunshot projectiles.

Of the three cases of gunshot wound involving the brachial artery, and completely dividing it, the primary hemorrhage did not prove to be excessive in a single instance. In one case the bleeding at first was profuse, but it soon ceased spontaneously. The humerus having also been extensively shattered by the projectile which severed the artery, the arm was amputated, and the patient ultimately recovered completely, notwithstanding the unfavorable circumstances under which the after treatment was conducted during a critical period in the clinical history of the case. In another case there was no primary hemorrhage whatever, aside from a slight capillary oozing. No secondary bleeding occurred, no operation was performed, and the patient recovered without the occurrence of any accident or any untoward event. In the third case the primary hemorrhage was so inconsiderable as not to be deemed of sufficient importance to require special mention. No operative procedure was demanded for its suppression. On the 18th day, however, secondary hemorrhage occurred. It was arrested by pressure applied to the place of injury, but returned on the following day. The bleeding vessel was then secured by two ligatures, of which the one was applied on the proximal, and the other on the distal side of the wound. The operation was successful in arresting the hemorrhage permanently, but the patient died thirty-nine days afterwards of pyæmia.

Of these three cases of gunshot wound, involving the brachial artery and severing it, one died and two recovered. In the fatal case, that result, as already stated, should be ascribed to the occurrence of pyæmia.

The following case presents us with an example of *gunshot division of the internal mammary artery*. It was contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

Case XXVII. *Gunshot Wound of Chest severing the Internal Mammary Artery; Primary Hemorrhage ceased spontaneously; Secondary Hemorrhage on Tenth Day while Coughing; Patient supposed to be scorbutic; Death from Exhaustion on Twelfth Day; Autopsy; a Coagulum weighing Eighteen Ounces was found in the Pleural Cavity.* ——,

Company A, 45th Illinois Volunteers, was wounded at the battle of Mission Ridge. The ball struck the edge of the sternum obliquely near its junction with the cartilage of the fourth rib, and emerged from the side of the thorax between the third and fourth ribs, a little more than three inches external to the orifice of entrance (on the left side). The wound extended through the parietes of the chest without injuring the lung or pericardium. For two or three minutes the hemorrhage was somewhat profuse, but it ceased spontaneously; the degree of shock was severe. After the hemorrhage had ceased, the man was transferred *in an ambulance* to hospital at Chattanooga.

For ten days the case progressed favorably (the wound looked well, but it was thought the patient was scorbutic), with every prospect of recovery; but while the patient was in the act of drinking water, coughing was excited, and hemorrhage supervened. Efforts were made by the attending surgeons to arrest the bleeding, by means of styptics, compression, etc., but without success. No attempt was made to place a ligature upon the vessel. The patient died from exhaustion, on the night of the twelfth day after he was wounded. There were no positive evidences of internal hemorrhage.

Post-mortem examination made twelve hours after death. A small piece of bone had been gouged out of the edge of the sternum; no fracture of sternum or ribs; pleura costalis cut through to the extent of nearly one inch; internal mammary artery severed; pleura pulmonalis and lung uninjured. *The pleural cavity contained a clot of blood weighing eighteen ounces.*

Is it not highly probable that ligature of the internal mammary artery would have saved the life of the patient, as ligature of that vessel was practicable, and the attending circumstances favorable?

Comments. — I believe that the question raised above by Dr. Clendenin, should be answered affirmatively. And why, let me ask, was the bleeding vessel not searched for and tied when the secondary hemorrhage occurred, in this case? The reply to this inquiry is contained in the report of the case, and is clothed in these words: "Efforts were made by the attending surgeons to arrest the bleeding by means of styptics, compression, etc., but without success." The truth of the matter is that inefficient means were employed for the purpose of arresting the hemorrhage in this case, and the means that might have proved effectual in controlling it were utterly neglected. The only effect which appears to have been produced by the use of styptics and pressure, was to cause the blood to flow internally instead of externally, and thus to accumulate in the pleural cavity. At the same time the secondary hemorrhage must have been profuse, for

Disastrous consequences of styptics and pressure.

it made its appearance on the tenth day, the patient died on the night of the twelfth, and, on making an autopsy, a coagulum weighing eighteen ounces was found in the pleural cavity. It would have been well for this patient if such agents for the relief of secondary hemorrhage, arterial in character, as styptics and pressure, had never been heard of, for then the attending surgeons would have been compelled to search for and tie the bleeding vessel, and thus his life would, in all probability, have been saved. It seems to me passing strange, that the relation in which the employment of styptics and compression stands to the employment of the ligature for the arrest of secondary hemorrhage, arterial in character, especially if it be profuse, should ever be overlooked by the surgeon. The reader must pardon me for stating in this place what I believe that relation to be, namely, the former should never be employed for the arrest of profuse secondary arterial hemorrhage, unless the ligature has failed to control the bleeding, or, from some inherent reason, cannot be applied with safety to the patient. Styptics and pressure should be used for the arrest of that form of hemorrhage, not from choice, but as remedies of expediency and of last resort.

A single remark should be made with regard to the primary hemorrhage which occurred in the foregoing case. Although it was rather profuse, for two or three minutes, it ceased spontaneously, because the vessel from which it came (the internal mammary artery) had been completely divided by the projectile, and thus was in a condition to permit occlusion of the bleeding orifice to spontaneously occur.

The next case is very interesting, instructive, and important. In it the *external carotid artery* was probably severed by a pistol-ball. The history of it has been contributed by Dr. Sanford B. Hunt, late Surgeon U. S. Volunteers, also formerly Professor of Anatomy in the University of Buffalo.

Case XXVIII. *External Carotid Artery wounded, probably divided by a Pistol-ball; Hemorrhage profuse, but arrested by Compression applied in the Wound, and did not return; Patient made a Good Recovery.* — At San Antonio, Texas, in the month of August, 1865, Lieutenant Van Giesen of the 18th N. Y. Cavalry, was accidentally wounded by a pistol in the hands of a comrade. The muzzle of the pistol was not more than three feet from the point of the entrance of the ball, which was on the right side of the neck, immediately opposite the superior border of the thyroid cartilage, and directly over the origin of the exter-

nal carotid artery. The point where the ball escaped was on the posterior part of the neck. The hemorrhage was great, being sufficient to render him very pallid and faint, but was promptly checked by an intelligent bystander by compression effected with the thumb applied *in* the wound. The first surgeon to reach the case was Dr. Settle, formerly Medical Director of the Confederate Army in Texas. On withdrawing the compression, as Dr. Settle informed me, the hemorrhage was renewed, a stream of blood, as large as a crow-quill, being thrown through the centre of a partially formed clot, to a distance of more than two feet, *per saltum*. It must have been over an hour after the wound was inflicted when I saw him. On again withdrawing the compression, no hemorrhage occurred. It was then 10 o'clock P. M.; the patient lay on the ground out-of-doors, good light could not be procured, and it was decided to defer the operation. An assistant surgeon was left with the patient, the instruments, etc., were put in readiness, and I expected to ligate the common carotid next morning, or perhaps during the night.

Next morning, however, the clot was firm, no hemorrhage occurred, and the policy of delay was adopted. About the eighth day the clot softened and came away without hemorrhage; the wound rapidly healed with hardly any perceptible suppuration (the ball had passed out posteriorly), and complete recovery resulted without operative procedure. *After recovery there was no pulsation in the temporal artery of that side, and some coldness and numbness of the face existed for a time.*

Comments. — This case gives us a good idea of the great value of pressure for the temporary control of certain forms of primary hemorrhage. There is good reason to believe that if pressure had not been promptly applied in this case, the patient would have bled to death before surgical assistance could have been brought to him. There is also a strong similarity between this case and that of General Arrighi, Duke of Padua, which was related by Baron Larrey, and has been referred to in another part of this essay. That officer was struck in the neck by a musket-ball at St. Jean d'Acre. It wounded his right carotid artery, the hemorrhage was very profuse, and he must have died on the spot if a soldier had not had the presence of mind to arrest the hemorrhage by introducing his two fore-fingers into the wound, and keeping them there, until Larrey arrived, and tied the vessel.

Local pressure for the temporary control of certain forms of bleeding.

Our case also shows us the method in which pressure can be most effectually employed for the temporary arrest of hemorrhage occasioned by gunshot wounds of arteries having a considerable size. That method consists in the introduction of the fingers or the thumb into the wound in order to directly compress the orifice or orifices in the bleeding vessel. In this way the bleeding can,

for the most part, be arrested with promptitude, with certainty, and with the expenditure of comparatively little physical force; for only a small amount of pressure is required to arrest the flow of blood, provided it is applied directly to the orifice in the wounded vessel. I say again that in this way the hemorrhage produced by gunshot wounds of arteries in the neck, axilla, and extremities, can generally be controlled until surgical assistance can be obtained, and the bleeding vessel properly secured by ligature. This remark is made with reference more especially to military practice. The circumstance that, in this case, the hemorrhage did not return after it had been arrested by pressure applied in the wound, to the bleeding orifice, by introducing the thumb, denotes that the injured vessel had been completely divided by the bullet.

Summary of twenty-three cases of gunshot wounds of arteries.

In the foregoing account of gunshot wounds of arteries, we have related or mentioned twenty-three cases, of which all but one occurred in the late war in this country. In all of them the injured vessel had a large size.

In three cases the artery was only partially divided. The vessels which suffered this lesion were *the axillary*, *the posterior tibial*, and *the popliteal*. The first two cases terminated fatally by hemorrhage, but the last recovered. In it a traumatic aneurism was formed in connection with the wounded popliteal artery (that vessel had been perforated by the bullet), the thigh was amputated, and thus the patient was rescued from impending death. Besides these three cases of partial division of important arteries by gunshot projectiles, a considerable number of examples of the same nature may be found further on in this essay.

In the remaining twenty cases, the injured vessel was completely divided by the projectile. In all but three of these twenty cases the primary bleeding ceased spontaneously.

Of these twenty cases thirteen died and but seven recovered. Of the whole twenty-three cases fifteen died and but eight recovered. This circumstance illustrates sufficiently the exceeding gravity of gunshot wounds involving large arteries.

Of the twenty cases wherein the wounded vessel was completely divided by the bullet, the femoral artery was the seat of the injury in five instances, of which all died; the popliteal in four instances, of which two died and two recovered; the posterior tibial in two instances, of which both died; the axillary in four instances, of which two died and two recovered; the brachial also in three instances, of which one died and two recovered; the internal mam-

mary in one instance which proved fatal; and the external carotid in one instance which recovered.

Of the thirteen fatal cases in which the artery was severed, two died of primary hemorrhage, two of secondary hemorrhage, five of gangrene, one of gangrene and secondary hemorrhage, one of pyæmia, and two of exhaustion.

There were in all eight cases of consecutive gangrene, of which but two were saved, and they by amputation of the thigh. The vessel injured was the popliteal artery.[1]

Of the eight cases of consecutive gangrene, the femoral artery was the seat of the traumatic lesion which produced it in two cases of the five related, wherein that vessel was completely divided, the popliteal in three of the four cases mentioned, the posterior tibial in both of the two cases reported, and the axillary in one of the four cases reported. Of the eight cases of consecutive gangrene, produced by gunshot severance of arteries, seven occurred in the lower, and but one in the upper extremity.

The analysis of these twenty cases shows that gunshot wounds dividing large arteries are not only very dangerous to life, but that they occasion death in certain determinate ways, the most important of which are primary hemorrhage, secondary hemorrhage, and consecutive gangrene. It shows further, that gangrene destroys more patients belonging to this category than all the forms of hemorrhage taken together.[2] I confess that when this result was first obtained from the study of these twenty cases it surprised me somewhat, but, after reflecting upon it, I do not perceive any good reason why it should be considered exceptional, and why it will not substantially obtain in a still larger collection of cases wherein important arteries belonging to the extremities are severed by gunshot projectiles.

Gunshot wounds severing large arteries very dangerous.

As this subject possesses much importance, the writer has taken some pains to collate Mr. Guthrie's experience concerning gangrene following gunshot wounds of blood-vessels. It appears that he saw seven cases belonging to this category in military practice. In three of them the popliteal artery was the vessel involved. In two of these three cases, it was found on dissection that the popliteal artery was completely divided; but in the other case it is only surmised that the wound of the popliteal artery was in the nature of a complete division of it, as no autopsy was made. In the remaining four cases it is believed that the femoral artery was wounded by a musket-ball in

Mr. Guthrie's experience concerning gangrene following gunshot wounds of arteries.

[1] Vide Case No. XVI.

[2] Battle-field hemorrhage excepted. See pp. 12, 13.

every instance. In one of them the occurrence of secondary hemorrhage made it necessary to secure the bleeding vessel at the place of injury. On cutting down upon it in that situation, it was found that the femoral artery and vein were wounded, "the former being half destroyed in its circumference." "A ligature placed above, and another below the wound, secured both artery and vein," and arrested the bleeding. On the third day afterwards mortification was evident, "*and on the fourth at mid-day he died, the limb up to the wound being nearly all in a gangrenous state.*" [1]

In another case possessing very great interest, both the femoral artery and vein had sustained a contused wound from a musket-ball. This soldier was wounded on the 10th of April, and on the night of the 26th, he died of consecutive gangrene. Dissection showed that the ball had passed between the artery and the vein; that the coats of the vein were but little injured, and those of the artery not destroyed in substance, although wounded; that the artery was much contracted in size at this spot, filled with coagulated blood, both above and below it, and completely impervious; that the vein was also filled with a coagulum, both above and below the wound, and totally impassable.[2]

In the third case the nature of the injury sustained by the femoral artery is not known, because no dissection was made; and in the fourth case it was found that the wounded artery "had yielded by ulceration, not having been cut in the first instance." [3]

Of these seven cases of consecutive gangrene, connected with gunshot wounds involving the femoral and popliteal arteries, it appears that, so far as known, the vessel was completely divided in but two instances, both of which pertain to the popliteal artery.

It also appears that every one of these seven cases of consecutive gangrene witnessed by Guthrie in military practice proved fatal. Amputation was resorted to in two instances, but without avail.

Guthrie's three cases of consecutive gangrene in private practice. All fatal.

Guthrie also states that he has seen three cases of mortification following wounds of the femoral and popliteal arteries in London. In one of them the femoral, and in two of them the popliteal artery, was the injured vessel. All of them proved fatal by the extension of the gangrene.[4]

It should also be stated before we dismiss this branch of the subject, that one of the most important of the reasons for the great fatality which attends consecutive gangrene produced by wounds

[1] Vide *Diseases and Injuries of Arteries*, pp. 235, 236, 237.
[2] *Op. cit.* pp. 241, 242.
[3] *Op. cit.*, p. 243.
[4] *Op. cit.*, p. 245.

of arteries, is the fact that *a distinct line of separation is but seldom formed in such cases.* This circumstance was also noticed by Guthrie. The consequence of it is, that the veins which proceed from the gangrenous part towards the trunk, being not closed or obliterated as they would be if a line of separation were formed, convey the decomposing blood from the gangrenous part, and pour it into the current of the general circulation. Thus systemic poisoning of a septic character is produced, and the patient's life is destroyed thereby.

In taking a comprehensive view of the subject of gunshot wounds of arteries, it appears that cases of partial division of the tube come under the surgeon's notice much more frequently than cases of complete division, at least so far as the important vessels are concerned. Thus Dr. Otis states: "In the few cases of primary gunshot lesions of the arteries that come under treatment, it was usually found that only a portion of the calibre of the vessel had been carried away, and that retraction had been thus prevented. But forty-four cases are entered on the records."[1]

Partial division of arteries by gunshot projectiles observed by surgeons more frequently than complete.

Treatment of Gunshot Wounds of Arteries. — With regard to treatment, the same writer remarks: "In most of them ligatures were placed above and below the seat of injury; but in a few instances the main trunk was tied at a distance, and amputation was practiced when the bleeding recurred. Twenty of the forty-four cases terminated fatally.[2]

Dr. Otis on treatment of gunshot wounds of arteries.

Considering the great fatality which attends the wounds of large or otherwise important arteries, the chief indication to be followed in their treatment is to obviate the tendency to death. When the main artery of a limb has been opened or severed by a gunshot missile, the question of most practical moment is, not how to save the patient's limb, but how to save the patient's life. Now, in cases belonging to this category, death is, for the most part, produced either by primary hemorrhage, or by consecutive gangrene, or by secondary hemorrhage. For the permanent arrest of hemorrhage, both primary and secondary, our chief reliance should be placed upon tying the bleeding vessel on both sides of the orifice in its walls, that is, at the place of injury. When this is not practicable, the main trunk should be secured by ligature at the nearest available point.

Author's observations on same subject.

With regard to consecutive gangrene in such cases, amputation

[1] Vide *Circular* No. 6, p. 39.

[2] Vide *Circular* No. 6, p. 39.

affords almost the only chance of saving the patient, and that chance is very small indeed, unless the operation is performed seasonably, that is, at a very early period. If we wait for a line of separation to form, we generally wait until it is too late to save the patient by this or any other expedient.

When the main artery of either of the extremities is wounded in connection with *gunshot fracture* of the corresponding bone, the case presents a much more serious aspect on that account. Even when dangerous hemorrhage does not occur, or has been arrested by ligature, the risk of consecutive gangrene is very much increased by this complication, *especially in the lower extremity.* When the femoral or the popliteal artery is wounded, and the thigh-bone broken, or the knee-joint injured, by a gunshot projectile, I believe it is always advisable to amputate without delay, because consecutive gangrene is almost certain to occur if the limb is not cut off, and because the performance of the operation during the primary period, would be much more likely to be attended with success, than its performance during the secondary period, or after gangrene has commenced. When the posterior tibial artery is wounded, and the bones of the leg broken by gunshot lesion, I believe it is also generally preferable to employ primary amputation, but especially in military practice in the field. In civil life, however, where the circumstances are usually much more favorable for conducting the after treatment, it may be advisable to attempt to save the leg when only one bone is broken, the comminution not extensive, and the laceration of the surrounding soft parts not great. In such a case occurring under circumstances favorable for the treatment, it may be advisable to properly secure the bleeding vessel in the wound, and then treat the case as a gunshot fracture.

In gunshot fractures of the humerus, accompanied by wound of the brachial artery, the chances of treating the case successfully, without amputation, are generally much greater than in corresponding lesions of the lower extremity. When the broken humerus is but little comminuted, the soft tissues surrounding it but little torn, and the accompanying nerves uninjured, it is generally advisable to properly tie the artery in the wound, and attempt to save the limb. But when the comminution is extensive, and the laceration of the soft structures great, primary amputation should be performed. In gunshot fractures of the fore-arm associated with corresponding wounds of arteries, however, it is but seldom necessary to amputate, unless the elbow-joint is injured; in such a case it is generally advisable to amputate without delay.

Again, when a gunshot wound of the femoral or the popliteal artery is attended with corresponding lesion of the vein, the bone being uninjured, primary amputation should always be performed.[1]

5. INCISED WOUNDS OF ARTERIES.

Importance of the Subject. — How Incised Wounds of the Arteries are inflicted. — Classification of these Wounds. — 1. Partial Division. — 2. Complete Division. — 3. Division of the Sheath and External Coat alone. — Incised Wounds of Arteries more prone to bleed than the other Forms of Vascular Injury. — It is more difficult to stop the Bleeding when Arteries are partially divided by Incised Wounds, than when the Division is complete. — Principles on which the Treatment should be conducted when a Small Artery is partially divided by a Cutting Instrument. — A Case in which the Brachial Artery was cut about half-way through by a Sabre Thrust near its Origin; Hemorrhage profuse, but immediately arrested with an Extemporaneous Tourniquet; the Vessel was tied on both Sides of the Orifice in its Walls with a Good Result. — An Important Case, in which the Occipital Artery was wounded; fatal Twenty-three Days afterwards from Repeated Hemorrhages, although the Common Carotid had been tied. — If the Artery had happened to be completely divided in this Case, it is probable that Pressure would have controlled the Bleeding; the Reasons stated. — On the Phenomena produced by the Partial Division of an Artery with a Sharp Instrument. — Concerning the Plan of Treatment which should be employed when Arteries are wounded with Sharp Instruments. — A Case of Incised Wound of the Arm involving the Axillary Artery; Profuse Hemorrhage which recurred Several Times; the Subclavian was then tied; Recovery. — In this Case the Hunterian Operation succeeded. — But it often fails in Similar Cases, either from a Return of the Bleeding, or from the Occurrence of Consecutive Gangrene. — The Old Operation is generally to be preferred in such Cases. — A Case of Incised Wound, completely dividing the Brachial Artery near its Origin; Death from Primary Hemorrhage in between Fifteen and Twenty Minutes. — A Case of Incised Wound of the Throat severing the External Carotid Artery; Death in about Twenty Minutes from Hemorrhage. — A Case in which the Popliteal Artery was severed with a Sabre; Traumatic Aneurism was produced; treated by the Old Method; Death some Time afterwards from Pyæmia. — A Case of Hernial Aneurism of the Brachial Artery, produced by an Incised Wound of its External Coat. — Description of Hernial Aneurism. — Remarks concerning Hernial Aneurism.

Arteries of great importance are not unfrequently wounded by cutting instruments. Chief among the dangers which attend incised wounds in general is the hemorrhage that occurs when blood-vessels of considerable size are opened in this way; and this danger is usually proportionate to the magnitude and inaccessibility of the injured vessel. The subject of hemorrhage from incised wounds of arteries is also of great interest to the surgeon, because in a large majority of all the cases of homicide or suicide in which death is produced by loss of blood, that occur so frequently in civil life, wounds of important arteries inflicted by cutting instruments are sustained. The same remark holds true with regard to most of those accidental injuries in which death is produced by hemorrhage. Importance of the subject.

Incised wounds of arteries are inflicted with knives of various

[1] Vide Case of Christopher Gross, No. XII.; also Mr. Guthrie's cases, mentioned on pp. 77, 78.

patterns and uses, with razors, with swords, and with a considerable variety of the edge-tools that are employed in the mechanic arts. These wounds are also inflicted by accidents, by design, and in war.

How incised wounds of arteries are inflicted.

When arteries are wounded by cutting instruments, the lesion consists either of partial division of the arterial tube, or of complete division of said tube, or the sheath and the external coat alone are divided, or the walls of the tube are punctured. But punctured wounds of arteries are produced by other instruments besides cutting ones, and therefore this form of injury constitutes a separate class, which has already been fully considered.

Classification of these wounds.

Incised wounds of arteries are more prone to bleed than contused or lacerated or gunshot wounds of arteries. The hemorrhage but seldom ceases spontaneously when large arteries are severed by cutting instruments, unless death is at hand. But the bleeding from contused and lacerated and gunshot division of arteries, having a similar size, not unfrequently stops of itself, as we have already shown. Incised wounds of arteries are characterized as a class by excessive hemorrhage, and they are more liable as a class to produce death by primary bleeding than any other form of vascular injury.

Incised wounds of arteries prone to bleed.

When a small artery is but partially divided by a cutting instrument, it is always more difficult to stanch the hemorrhage than it is when the vessel is completely divided. Thus in abstracting blood from the temporal artery (arteriotomy), when it becomes necessary to arrest the sanguineous flow, the first thing to be done is to divide the artery completely at the place where it has been opened, and then a moderate amount of pressure applied at the place of division will generally suffice to arrest the bleeding permanently. But if the division of the artery be not completed in such a case, if pressure be applied for the purpose of arresting the outflow of blood while the arterial tube is still only partially divided, then it generally follows that either a traumatic aneurism is formed at the seat of the wound, or a series of secondary hemorrhages occur which may place the patient's life in jeopardy, even where an artery so small as the anterior branch of the temporal is the vessel involved in the traumatic lesion. In cases of incised wounds of arteries where the vessel is small in point of size, the first thing to be done for the purpose of arresting the hemorrhage from it if it happens to be but partially divided, is to complete the division. Thus we perceive that the treatment of

Treatment when a small artery is partially divided.

incised wounds of arteries must be conducted on principles somewhat different from those which obtain in the case of contused and lacerated and gunshot wounds of the blood-vessels. Hemorrhage from incised wounds of blood-vessels is less likely to cease spontaneously than hemorrhage from the other forms of vascular injury, and hence the assistance of the surgeon is more likely to be required in order to restrain it permanently.

The following case affords an excellent example, in which the *brachial artery* was cut about half-way through its calibre, near its origin, by a sabre-thrust. The wound was inflicted by an old soldier while in the discharge of his duty. Seeing the hemorrhage arterial in character, he arrested it promptly by the application of an extemporaneous tourniquet, and the patient was sent to hospital. After arriving there, although the wound did not bleed at the time, he was treated by his attending surgeon in such a way as to save his life from peril, and to cause his recovery in the smallest possible space of time. This case was related to the writer by Professor J. W. S. Gouley.

Brachial artery wounded by a sabre-thrust.

Case XXIX. — *Incised Wound of Brachial Artery near its Origin, inflicted with a Sabre; Hemorrhage profuse, but arrested immediately with an Extemporaneous Tourniquet; tied the Vessel on both Sides of the Orifice in its Walls with a Good Result.* — Private John Williams, Company A, 6th Pennsylvania Cavalry, aged 26, was admitted to the E Street U. S. Army General Hospital (Washington Infirmary), September 20, 1861, about one hour after having been wounded by a sabre-thrust in upper part of left arm, while resisting arrest for drunkenness and insubordination, as was reported.

The weapon penetrated the arm from without inward and backward, in such a way as to transfix the biceps muscle, and *wound the brachial artery about one inch below its origin.* Very considerable hemorrhage occurred in jets at the time; it was, however, promptly arrested by the application of an extemporaneous tourniquet, made by tying a handkerchief around the arm above the wound, and twisting it tightly with a piece of wood inserted beneath it. He consequently did not present an exsanguinated appearance when he reached the hospital. The external wound was situated on the front of the arm near its upper end, and was about one inch in length. It was filled with coagulated blood. On loosening the tourniquet bleeding did not occur, but it was found that there was no radial, nor ulnar, nor brachial pulse. The nature of the injury could, therefore, not be mistaken.

Dr. Gouley proceeded to tie the wounded brachial artery, not by dilating the wound that already existed, but by cutting directly down upon it at the place where it was injured, as he would have done if no wound

of the soft parts in front and to the outer side of the artery had been present. He found the *artery cut about half-way across*, in a nearly transverse direction, about one inch below its origin as already stated. He secured it by two ligatures, of which one was applied on the proximal, and the other on the distal side of the orifice, at a little distance from said orifice. He cut out the pathological specimen then lying between the two ligatures, and subsequently sent it to the Army Medical Museum. He applied the proximal ligature first. One of the venæ comites was wounded, and required the application of a ligature to arrest the bleeding from it. Warm dressings were applied to the whole limb for the purpose of maintaining its temperature.

Next day the hand, fore-arm, and arm were swollen and œdematous; applied a roller bandage evenly and carefully to the swollen parts.

The ligatures (both) were removed from the wound of operation on the eighth day.

The swelling lasted a considerable time, but finally disappeared. It should be stated that the patient's habits were intemperate.

October 16. — Twenty-six days after the wound was inflicted, he was discharged from the hospital cured.

Wounds of occipital artery.

In the history of the next case it is stated that the *occipital artery* was wounded by a stab, but we are not informed whether the vessel was only partially or completely divided. I think, however, we can safely infer from the clinical history of the case that the severance was but partial.

CASE XXX.— *Incised Wound of Occipital Artery in Occipital Groove; fatal Twenty-three Days afterwards from repeated Hemorrhages, although the Common Carotid Artery had been tied.* — A young man of twenty-two was stabbed behind the left ear in a fight, and half an hour afterwards was seen by a medical man. He was then pale and faint from loss of blood. The wound was located about two inches behind the auditory meatus, and was about two inches in length by one inch in depth. The bleeding still continued in feeble jets; but pressure with the finger applied at the bottom of the wound controlled it completely. Not succeeding in the endeavors made to grasp the artery with forceps, it was resolved to treat it by pressure. The wound was filled with lint, and then its lips were approximated and secured by sutures. This proceeding controlled the hemorrhage for five days, when a slight bleeding occurred. On the sixth day there was more hemorrhage. On removing the dressing the bleeding was very profuse, and could not be entirely arrested by pressure with the finger applied in the same way as before. The common carotid of that side (left) was then tied, and the bleeding ceased. Three days afterwards a slight hemorrhage occurred at the original wound. Twelve days later still, hemorrhage again occurred

from the original wound, on opening which it was found that the blood escaped from a point just inside of the mastoid process in the situation of the occipital artery. This bleeding was treated with manual compression applied unremittingly by the attendants. Two days subsequently he died. This was twenty-three days after the infliction of the injury, and seventeen days after the carotid was tied. Convulsions set in eighteen hours before death. The *right* arm and *right* leg were found to be paralyzed *ten* days before death, or *seven* days after the operation. The wound was on the *left* side, and the *left* carotid artery was tied.

Pulsation was felt in the left temporal artery five days after the operation.

The *post-mortem*, ten hours after death, showed that the wound had extended in between the mastoid process and the transverse process of the atlas, wounding the occipital artery in its passage along the occipital groove. The carotid artery was perfectly occluded. *Brain apparently healthy.*[1]

Comments. — It is probable that, in this case, if the occipital artery had been completely divided at the outset by the instrument which inflicted the wound, the treatment by pressure afterwards would have been entirely successful. The ends of the divided vessel would have contracted to such extent as to diminish their calibre very much, and, at the same time, they would have been retracted within the arterial sheath so as to become separated from each other for a little distance. The effect of contraction of the bleeding orifices would be to diminish the size of the hemorrhagic streams in a corresponding degree. The effect of retraction of the ends of the divided vessel within its sheath would be to afford a more secure lodgment for a clot of blood of such sort as would arrest the bleeding. Now, if external pressure should be applied to an occipital artery thus circumstanced, at the place of injury, it is not difficult to perceive that the hemorrhage would probably be completely suppressed at once, and that the arrest of the hemorrhage would also be likely to prove permanent.

Precisely the same thing would have happened to the severed occipital artery, as we see take place in abstracting blood from the temporal artery, namely, on completing the division of the vessel and applying pressure at the place of operation by means of a compress and bandage, the further escape of blood is immediately prevented, and does not return.

But this patient was not blest with any such good fortune. He suffered a frequent repetition of the hemorrhage from the wounded

[1] Vide *American Medical Times*, May 18th, 1861, p. 320.

vessel, and finally lost his life from it. And why, let me ask, did this take place? The only satisfactory answer we can make is that the wounded occipital artery was partially but not completely divided.

Phenomena produced by partial division with a sharp instrument.

Now, the phenomena produced by the partial division of an artery with a sharp instrument are the following: When the vessel is divided transversely to the extent of one fourth of its circumference, the wound gapes open in such a way as to become circular in shape, by reason of the contraction of the muscular and elastic fibres belonging to its coats. When the vessel is divided to the extent of one half of its circumference, the orifice assumes an elongated or oval shape from the operation of the same cause. Where three fourths of the artery are divided, the slip which remains prevents the retraction of the under part of the artery, but the upper parts are separated to a considerable distance, giving to each the shape of a pen cut for writing.[1] The consequence is, that in the case of an incised wound of an artery, the size of the hemorrhagic stream is never lessened by a diminution in the calibre of the vessel itself from the spontaneous contraction of its muscular coat, for, in the case supposed, no such contraction takes place; and retraction within the sheath being impossible, no facility is afforded for the lodgment of a clot of blood to plug up the bleeding orifice securely. The further consequence is, that in cases of this description, when treated by pressure, the hemorrhage, although it is arrested by it for the time being, recurs again and again, until the patient's life is destroyed. Such is precisely what happened in the case now under consideration.

Treatment when arteries are wounded with cutting instruments.

The treatment best adapted for the relief of this class of patients, therefore, becomes a matter of great importance. If reliance be placed upon local pressure alone, the result will probably be fatal. If the main trunk be tied at a distance from the seat of injury, the hemorrhage will be apt to return, and in the end destroy the patient, especially if the wounded artery belongs to a part where the vascular connections by anastomosis and otherwise are as free as they are in the head, face, and neck. The plan of surgical treatment most likely to prove successful in a case where the occipital artery has been partly divided by a cutting instrument, as it was in the case now under consideration, consists in securing the bleeding vessel at the place of injury by two ligatures, one of which should be applied on the proximal, and the

[1] Guthrie, *Diseases and Injuries of Arteries*, p. 211.

other on the distal side of the orifice in it. This plan of treatment, which is dictated by reason and sanctioned by experience, was employed by Professor Gouley, it will be recollected, in the case of Williams (No. XXIX.), where the wounded vessel was very much larger than the occipital artery, and with gratifying success. It has also been employed in many similar or analogous instances during the late War of the Rebellion with a success equally gratifying.

Case XXXI. — *Incised Wound of Arm involving the Axillary Artery; Profuse Hemorrhage which recurred several Times; Ligature of Subclavian Artery; Recovery.* — Dr. H. N. Bennett relates the following case: A man, aged 20, was accidentally stabbed with a long, narrow knife, the point of which entered on the posterior and outer aspect of the arm, a short distance above the insertion of the deltoid, passing directly upwards and inwards, a distance of at least three inches, the edge being turned towards and running close to the bone. The hemorrhage was profuse, and Dr. James Baldwin was immediately called. Upon his arrival the patient was already faint from loss of blood, and it was not difficult at this time to arrest the bleeding. A roller bandage was applied the whole length of the limb, and a firm compress over the wound. There was no pulsation in the radial artery. The hemorrhage remained quiescent several days, when it broke out with renewed force, and unmistakably arterial. At this stage of the case Dr. Bennett first saw the patient. The whole limb was now swollen, the arm being to considerable extent infiltrated with blood, while the fore-arm and hand were œdematous. The wound was then filled with the persulphate of iron, compression being continued as before. The hemorrhage had now another period of quiescence, and the swelling of the limb materially lessened, but on the eighth day after the application of the styptic, bleeding again commenced, with still greater violence, and was with much difficulty arrested by compression. The limb immediately swelled again, and the œdema of the fore-arm and the hand was greater than before. The patient was now suffering the constitutional effects of loss of blood — his face was blanched, his appetite poor, and his pulse frequent and feeble. Dr. Bennett believed it high time to secure the patient from further hemorrhage, if possible, and with this view proposed to ligate the subclavian artery. An attempt to tie the wounded vessel by following the incision (only three fourths of an inch in width), would involve the muscles of the arm to an unwarrantable extent, and perhaps also important nerves. Moreover, it was quite uncertain as to what artery had been severed or *wounded;* and the anastomoses about the shoulder being quite free, Dr. Bennett believed the ligation of the subclavian to be the most judicious method of treatment.

Dr. Bennett performed the operation, October 12, 1862, assisted by

Dr. Baldwin. No details are necessary, as the vessel was tied in the usual manner and place, just without the scaleni muscles. The infiltration of blood and the œdema disappeared almost entirely within forty-eight hours, and the temperature of the limb was easily maintained by an envelope of flannel. The ligature came away on the thirteenth day, the operative incision being nearly healed. The original wound began to cicatrize, and was firmly closed at the end of three weeks after the operation. No pulsation is yet visible in either the radial or the ulnar artery, although the man is in good health, and pursuing his ordinary avocation.[1]

Comments. — This case affords an apposite illustration of a statement already made concerning the influence exerted by the peculiarities of the wound in the soft parts external to a wounded artery, in modifying the hemorrhage from it. This patient sustained a wound of the axillary artery (it is probable), but the instrument which inflicted it reached that vessel by pursuing an oblique or indirect course, making thereby a long and narrow incision. The consequence of this peculiarity of the wound was that the escape of blood from the injured vessel was retarded, and thus it happened that a patient's life was prolonged until surgical assistance arrived, who would probably have died of hemorrhage before such assistance could have been obtained, if the incision had been of large size and penetrating perpendicularly down to the injured axillary artery.

It is an interesting fact that the Hunterian operation for aneurism proved successful in permanently arresting the bleeding in this case; but while the result in this particular instance is very gratifying, it should not be forgotten by the surgeon, that, in numerous instances where the axillary artery has sustained an incised wound similar in character to that witnessed in the foregoing case, the ligature of the subclavian artery, although it arrested the bleeding for the time being, has in the end proved unsuccessful, being followed by a return of the hemorrhage from the wounded vessel, especially from the distal portion of it, or by gangrene, which sooner or later proved fatal. The writer therefore cannot avoid thinking that it would have been preferable to tie the axillary artery at the place where it was wounded, applying both a proximal and a distal ligature, for he feels confident that a much larger proportion of cases of this nature would be saved by performing this operation than by tying the artery above the clavicle.[2]

Hunterian operation successful.

The old operation preferred.

[1] Vide *American Medical Times.*

[2] Vide Mr. Syme's Case of Axillary Aneurism.

Moreover, in order to secure the bleeding vessel at the place of injury, it would not have been necessary to follow the track of the original wound. The preferable course would have been to cut directly down upon the artery at the place where it was wounded, as Professor Gouley did in Case XXIX., and then, after having exposed the vessel at the seat of injury, to secure it by two ligatures, one applied on the proximal, and the other on the distal side of the wound.

In the next case, a man was stabbed with a knife in such a way that his brachial artery on the right side was divided, and he died of hemorrhage before surgical assistance could be obtained.

Case XXXII. *Incised Wound completely dividing the Brachial Artery near its Commencement; Death from Primary Hemorrhage in between Fifteen and Twenty Minutes.* — A middle aged man, named John Heavy, was stabbed in the upper part of the right arm with a knife on the night of May 3d, and, according to the statements of the police and others, bled to death in fifteen or twenty minutes — in not less than fifteen nor more than twenty minutes.

Autopsy made at four o'clock, P. M., May 4th, at the Fourth Ward station-house. Cadaver large and muscular. Face, lips, and surface of body generally, very pale, and present a waxen appearance. There is an incised wound on the anterior and inner part of the right arm, a little way below the fold of the armpit; this wound is one inch and a quarter in length, and extends obliquely across the arm. It is about two inches in depth, and involves the brachial artery, which has been severed, transversely, near its origin. The ends of the divided vessel were partially contracted, but not plugged up with coagulated blood. The wound of the soft parts exterior to the vessel was filled with clotted blood. The lungs, liver, spleen, and internal organs generally, contained much less than the normal quantity of blood. The heart was large and fatty. Its right side contained some blood. The foramen ovale was closed. There was some atheromatous disease in the ascending aorta.

The autopsy of this case was made by the writer.

In the following case the *external carotid artery* was divided with a knife.

Case XXXIII. *Incised Wound of the Throat severing the External Carotid Artery, etc.; Death in about Twenty Minutes from Hemorrhage.* — William Berren, a sail-maker, aged about 32, was stabbed during an affray in Water Street, on Saturday night, December 11th, and bled to death in about twenty minutes, according to the statements of those who were acquainted with the circumstances attending his death.

Autopsy at Fourth Ward station-house, December 13th, twelve o'clock M. Face, lips, gums, and surface of whole body pale and exsanguinated. External examination showed the presence of three separate incised wounds, namely, one having a length of two and one half inches, situated on the left side of the neck, commencing anterior to the ear, and extending forward and somewhat obliquely downward, just beneath and nearly parallel to the body of the lower jaw; another, also about two and one half inches in length, located behind the summit of the left shoulder — a "flesh wound," and, therefore, of minor importance; and the third, about one and a half inches in length, situated in the anterior part of the left lumbar region just beneath the short ribs. The direction of this incision through the skin was obliquely upwards and forwards. A piece of the omentum was hanging out of this wound, and I readily passed my finger through it into the cavity of the abdomen, which was the portion of the body next examined. On following the track of the wound last mentioned, it was found to perforate the abdominal walls, to traverse the descending colon from side to side, transfixing it, to penetrate the psoas magnus muscle, and to terminate at the spinal column. Some fæces had escaped through the wounds of the intestine into the peritoneal cavity. There was also some extravasated blood in the tissues involved by the wound, and in the peritoneal cavity near the wound. The direction of its track was from the exterior of the body nearly at right angles to the long axis of the trunk, varying from it slightly downward.

On making a more critical examination of the wound in the throat, I found that its lips were drawn together with a single point of interrupted suture, that they were somewhat irregular in shape, and that the track of the wound extended almost transversely across, and nearly through the throat, severing, in its course, the anterior third of the left sterno-mastoid muscle, *the left external carotid artery near its origin*, and the accompanying vein; that it passed through the muscles at the root of the tongue, cutting off the epiglottis at its base; that it divided the great cornu of the hyoid bone on the right side, and terminated near the anterior margin of the right sterno-mastoid muscle. There was some clotted blood in the larynx below the rima glottidis. The stomach contained a few ounces of matter resembling coffee-grounds, which was probably blood that had been changed by the action of the gastric juice. The gastric mucous membrane was redder than natural. The lungs contained less than the normal quantity of blood, but in other respects were sound. Heart natural in structure. Liver rather large and paler than natural, with spots of commencing fatty degeneration on convex surface of right lobe. Kidneys sound.

The extremities of the severed external carotid artery were somewhat contracted, but were not plugged up with coagulated blood. The wound in the neighborhood of this vessel contained clotted blood.

The *autopsy* of this case also was made by the writer.

Comments. — The last two cases have been introduced here for the purpose of showing the length of time during which a man survives when he has received an incised wound with complete division of an artery of the size of the external carotid or the brachial near its origin, although no efforts whatever are made for the suppression of the hemorrhage. In both cases careful inquiry was made in order to ascertain how long the man lived after he was stabbed. To this end all the parties cognizant of the respective transactions were questioned on this point. As both cases were thoroughly investigated by the coroner, unusual facilities were afforded for pursuing this inquiry. In neither of them was any effort of importance made to arrest the hemorrhage. In both of them the loss of blood was the cause of death. As already stated the one who sustained a division of the brachial artery near its commencement died in not less than fifteen nor more than twenty minutes after the wound was inflicted. The other one had his external carotid artery on the left side cut off near its origin, and died in about twenty minutes afterwards.

How long a man survives when his brachial or external carotid artery is severed.

In both cases the ends of the divided arteries were partially, that is, somewhat contracted, but they were neither filled nor plugged up with coagulated blood, and were therefore patulous.

In the next case the *popliteal artery* was cut in two with the point of a sabre.

Case XXXIV. *Incised Wound of the Popliteal Artery, completely dividing it, inflicted with a Sabre; followed by Traumatic Aneurism; treated by the Old Method; Death on the Thirty-eighth Day after the Operation, with Symptoms of Pyæmia;* Case related by Deschamps. — Étienne Repasses, a servant, aged 41, was admitted to the La Charité Hospital, May 9th, for a stab in the ham, inflicted with the point of a sabre.

The wound was situated at the posterior, inferior, and external part of the thigh, and penetrated to the popliteal artery. There was a circumscribed aneurismal tumor, about the size of a turkey's egg, and having a strong and visible pulsation. The leg was much swollen, especially about the calf. The state of the patient was rendered still more alarming in consequence of a catarrhal affection, which had come on rapidly the day after the wound, accompanied by much fever, oppression, and sleeplessness; the expectoration was very abundant and suspicious in appearance. The operation could not, consequently, be had recourse to at present; we therefore contented ourselves with applying a bandage methodically on the foot and leg, and graduated compression on the

femoral artery. The pains in the wounded part were not very severe for some time; but they, as well as the swelling of the leg, increased from the 14th to the 20th, though the aneurismal tumor did not appear to undergo any change. On the 20th of June, the condition of the patient, as far as the chest was concerned, appearing improved, and the fever, as well as the quantity of the expectoration, being diminished, I decided to perform the operation, which was accordingly done on the same day.

The patient having been laid upon his belly, I cut down upon the tumor in the direction of the artery, dividing first of all the skin, and afterwards the cellular tissue, with all the precautions necessary to avoid implicating the nerve, which I carefully sought for. The skin and cellular tissue having been divided to an extent of six fingers' breadth, I found the nerve, by the side of which, towards the internal part of the ham, I continued the dissection until I had penetrated into the aneurismal sac. Then separating the nerve with the fingers of the left hand, I opened the sac upwards and downwards.

I next removed all the clots, and having washed and sponged out the whole of the interior of the sac, could then observe its extent, and the situation of the wound in the artery, which could readily be seen; *it cut the vessel completely across.* The state of the parts was such that the end of the finger could readily be introduced into the artery where it was divided. I loosened the tourniquet, and the free escape of the blood confirmed me in my opinion as to the situation of the wound. We observed that this was not at the deepest part of the sac, as commonly happens, but that it was somewhat to the outside, in consequence of which the application of the ligature was easier. I employed the same needle, in the same way, and with the same ease as before, *passing a waxed thread under the artery, about four lines below the wound in it;* the thread was then tied with a common knot.

I then applied the upper ligature at nearly an equal distance from the wound in the artery.

At noon, on the same day, the leg was nearly of its natural temperature, but the foot was cold and insensible; warm spirituous fomentations were employed uninterruptedly. In the evening the foot appeared to me not quite so cold, which I might have attributed to the hot linens that constantly enveloped it, if sensibility had not returned to a certain degree. This sensibility was more distinct on the following day and the day after that; but still the foot became cold whenever the hot linens were removed; it was not till the following day that the toes acquired a little warmth; on the next day they were in their natural state.

On the 2d of July, the twelfth day after the operation, observing that all the parts included in the noose of the superior ligature were divided, I removed the serre-artère. Two days afterwards the lower ligature became so loose as to enable me to pass a grooved director into its

noose, and to divide it. The sensibility and temperature of the part were natural, but the swelling of the leg had not diminished. A deep and painful swelling in the gemelli and soleus muscles terminated in an abscess, the pus of which emptied itself into the wound; in the lower angle of which I made an incision in order to make the communication easier.

About the 20th of July, a month after the operation, the patient was attacked with an obstinate diarrhœa; irregular shiverings, vomiting, and fainting fits then came on, the pus became fetid and serous, and he died on the 28th of the same month, the thirty-eighth day after the operation.

The foregoing account of the case has been condensed from Deschamps' report.[1]

Comments. — It was an important and almost an unique feature of this case, that *the vessel* from which the traumatic aneurism was developed in the popliteal region, *had been completely divided by the point of the sabre*, when it inflicted the wound at the outset. It is not by any means a common occurrence for a traumatic aneurism to be formed at the extremity of a divided artery. The kind of injury to blood-vessels which is usually associated with the formation of traumatic aneurism, is either a punctured wound, or a lesion of such a character as to involve only a partial division of the arterial tube. Experience has shown that this obtains in a very large majority of the instances of traumatic aneurism. In another place we shall present an account of another case, wherein a traumatic aneurism was developed from the proximal extremity of an axillary artery which had been severed by a carbine-shot; and we propose there to make some additional observations upon the subject.

Traumatic aneurism seldom occurs when the artery is completely divided.

In the next case the *external coat of the brachial artery* was wounded with an amputating knife, and a rare variety of traumatic aneurism was produced in consequence.

Hernial aneurism.

Case XXXV. *Aneurism of Brachial Artery occurring in the Stump after Amputation of Arm, and occasioned by Excision of the External Coat of the Vessel through a Small Space with the Amputating Knife; Hemorrhage from Rupture of the Aneurismal Swelling; Reamputation; Recovery;* Case reported by G. W. Smith, M. D., of Plainfield, Penn., in the "American Journal of the Medical Sciences," October, 1865, pp. 417, 418. — John Finley, private, Company E, 3d Massachusetts Artil-

[1] Vide *Observations on Aneurism*, Sydenham Society edition, p. 410, *et seq.*, London, 1844.

lery, admitted to White Hall Hospital, August 24th, 1865. This man's right arm had been amputated, August 19th, very close to the elbow-joint, in consequence of a severe injury of the right fore-arm, the result of the premature explosion of a shell fired from his own gun. The form of the operation was the anterior and posterior flap. On admission the man's general health was *very* much better than could have been expected under existing circumstances; he ate well, slept well, and suffered but little pain; his bowels were regular, tongue clean, skin healthy, pulse seventy-eight and of good volume. These happy indications are severally alluded to, because it is thought their existence is somewhat remarkable in conjunction with a stump five days after amputation, the condition of which is decidedly unhealthy, not only at the point of operation, where the flaps are pale, flabby, and by their appearance would seem to indicate a decided lack of constitutional vitality, but throughout its whole extent being severely and deeply burned. The left arm, shoulder, and breast were also badly burned. The treatment consisted of nutritious food and porter, with the local application of warm water; as a stimulant, an occasional touching of the wound with acid. nitric, ℥i. to aq. ℥i. was resorted to.

On the night of August 27th, *secondary hemorrhage occurred*, of an alarming character; *the bleeding was finally arrested by pressure*, after at least twenty-five ounces of blood had been lost. From this time until August 31st, the patient did comparatively well; on the morning of this day the hemorrhage recurred, and a board of medical officers was called to see the patient in consultation. At this time the burned arm was in a very unpromising condition, for though not actually sloughing, there was every indication that such an event would soon occur. It was also discovered that the circulation in the part, from some cause, was abnormal. *After careful examination, an opinion was formed that an aneurism of the brachial artery existed.* The unhealthy condition of the burned stump, it was thought, promised badly for the success of ligation, and it was decided to reamputate. The circular operation was performed near the shoulder-joint. Very little hemorrhage occurred. Anæsthetic used, consisted of chloroform one part, ether four parts.

An examination of the amputated portion showed a well-formed *aneurism of the brachial artery*, existing about two and a half inches above the point of application of the ligature. *The two inner coats of the artery were intact, and formed the walls of the aneurismal tumor. The external coat was deficient, a small portion of its circumference having been shaved off by the knife of the operator in cutting the anterior flap at the first amputation. Through this opening, or ring, the aneurismal tumor protruded, reminding one of the protrusion of a femoral hernia through its ring. The edges of the ring were bold and well defined, and the tumor itself consisted of a well-marked neck and body; that portion of it within the circumference of the ring being constricted to the diameter of one*

Description of hernial aneurism.

eighth of an inch, the protruded part or body measuring at least half an inch in diameter. It was discovered that the hemorrhage proceeded from a rupture in the walls of the aneurism.

The secondary amputation did very well, and the patient was transferred to his own State, October 29th, with a stump entirely cicatrized.

Remarks by the Dr. Smith who reported the Case. — "By this case two points of special interest are presented to the surgeon. The first is, that the knife of the operator, in performing a flap amputation, may so wound an artery as not to be perceptible at the time, and yet give rise to very serious secondary results. Again, this case proves that the walls of an aneurism are not always formed by the external coat of an artery; neither are they always formed by the dilatation of all the coats; nor are they always produced by the condensation of the cellular tissue lying exterior to the vessel in cases of traumatic aneurism; but they may be formed by the dilatation of the internal tunics, the outer one being, from some cause, injured. In the case now under consideration, the external coat was certainly injured by the knife. At first it was thought that the lesion which said coat had sustained might have been the result of a direct injury to the vessel, inflicted at the time of the explosion of the shell; but the healthy condition of all the coats, and the smooth *cut* edges of the wound in the fibrous tunic, as seen at the autopsy of the part last amputated, precluded the latter supposition." How produced.

The variety of traumatic aneurism which occurred in the case just related is called *hernial*, from its fancied resemblance to the appearance presented by intestinal protrusion in cases of umbilical, inguinal or femoral rupture. Mr. Holmes, however, seems inclined to doubt whether hernial aneurism ever occurs;[1] but the foregoing example seems to place the matter beyond question.

[1] Vide *System of Surgery*, vol. iii. p. 347.

CHAPTER FOURTH.

ON TRAUMATIC ANEURISM.

This Accident was well known to the Ancient Surgeons. — Galen was the Earliest Writer on this Subject. — Five Cases of Traumatic Aneurism have already been related in this Essay. — The First resulted from a Punctured Wound. — The Second from a Lacerated Wound. — The Third from a Gunshot Wound. — The Fourth from an Incised Wound. — The Fifth was an Example of Hernial Aneurism. — Two Principal Varieties of Traumatic Aneurism recognized: 1. the *Diffused*; 2. the *Circumscribed*. — Pathology of the Diffused Variety. — Pathology of the Circumscribed Variety. — Two Exceptional Forms of the Circumscribed Variety also mentioned. — An Illustrative Case of Circumscribed Traumatic Aneurism of the Femoral Artery produced by a Bayonet Wound, contributed by Professor Gouley. — The Way in which this Variety of Aneurism is not unfrequently produced. — Traumatic Aneurism is, in Reality, a Variety of Arterial Wound in which the External but not the Internal Bleeding has ceased. — A Case in which the Axillary Artery was severed by a Carbine-ball; Circumscribed Traumatic Aneurism appeared on the Twenty-first Day; Ligature of the Subclavian; Death Forty-six Days afterwards from Exhaustion, produced by Secondary Hemorrhage and Suppuration. — *Comments.* — Concerning Hemorrhage from Wounded Arteries. — On the Means by which the Bleeding stops of itself when Large Arteries are Severed by Gunshot Projectiles. — Why Arteries are more liable to bleed when partially than when completely divided. — Concerning the Surgical Treatment of Primary Hemorrhage. — On the Causes of the Aneurismal Murmur and Thrill. — Why the Murmur and Thrill are sometimes not present. — Pathology of the Aneurismal Swelling in the Case just related. — Pathology of the Secondary Hemorrhage which occurred in the same Case. — It did not occur from the Distal End of the Severed Artery. — It did occur from the Proximal End through Reflux of Blood in the Branches of the Axillary when the Collateral Circulation got well established. — The Old Operation should have been performed in this Case. — The Reasons why stated. — These Views are corroborated by Sir Charles Bell's Case, which is here related. — Surgical Treatment of Traumatic Aneurism in general. — The Ancient Surgeons were acquainted with Excellent Methods of treating this Lesion. — Galen, Aëtius, and Paulus Ægineta referred to. — Of the Operation of Antyllus, now frequently called "the Old Operation." — Albucasis and Haly Abbas also referred to. — Treatment of Diffused Traumatic Aneurism. — The Old Operation generally to be preferred. — Treatment of Circumscribed Traumatic Aneurism. — Objections to the Plan of Hunter in such Cases. — It may fail through inducing Consecutive Gangrene or Secondary Hemorrhage. — The Old Operation less likely to be followed by these Disasters. — The same Subject continued. — Mr. Syme deserves much credit for reviving the Old Operation. — An Illustrative Case in which the Old Operation was performed with an Excellent Result. — Immense Pouch-shaped Aneurism of the Femoral Artery, produced by Gunshot Injury; treated by tying the Vessel on both the Proximal and the Distal Side of the Orifice with a Good Result. — Concerning Distal Hemorrhage in this Case. — Description of the Aneurismal Sac. — Progress of the Case after the Operation very satisfactory. — How the Difficulties attending the Performance of the Old Operation in Cases such as the Foregoing may be obviated. — Rules laid down. — Additional Remarks concerning the Treatment of Traumatic Aneurism of the Axillary Artery. — The Plan of Treatment should be adapted to meet the Peculiarities of Traumatic Aneurism in Special Cases. — A Case of Traumatic Aneurism of the Femoral Artery occasioned by Gunshot Injury; Secondary Hemorrhage occurred Several Times; cured finally by opening the Sac and tying the Artery both above and below the Place of Injury. — We generally prefer the Old Operation to that of Hunter and Anel, because it is more likely to prove successful. —

The Hunterian Operation does not always fail in such Cases. — An Illustrative Instance related. — Another Illustrative Case narrated, in which the Operation of Anel was followed by Traumatic Gangrene. — The Femoral was the Artery that was involved. — The Limb was amputated in order to obviate the Consequences of Gangrene, and the Patient finally recovered. — The Plan of Hunter is, however, sometimes preferable to the Old Operation in Cases of Traumatic Aneurisms of the Leg and Ham. — Dupuytren was the first to conceive and execute this Proposal. — An Illustrative Case that occurred in Dupuytren's Practice. — The Reasons which led him to operate on the Plan of Hunter stated. — Dupuytren's Observations on this Point very interesting and instructive. — Delpech subsequently treated a Similar Case in the same Way with a Good Result. — Dupuytren also treated a Gunshot Case on the same Plan with Success. — Dupuytren's Objections to Amputation in Cases of Traumatic Aneurism, produced by Simple Fracture. — His Objections to the Old Operation also stated. — Much Injury may be done by attempting the Performance of an Impracticable Operation. — When the Fracture is compound, it is generally preferable to perform the Old Operation, or else to amputate. — Mr. Holmes' Remarks concerning Traumatic Aneurism complicating Fracture. — Résumé of the Surgical Treatment of Traumatic Aneurism required in the several Surgical Regions of the Body. — Popliteal; Femoral; Iliac; Carotid; Axillary; Brachial; Radial; Ulnar; and the Palmar Arch. — The next Two Cases illustrate the Distressing and even Deplorable Circumstances under which the Surgeon must sometimes operate for Traumatic Aneurism. — In the First of them the Result was good. — In the Last, Recovery might have taken place if the Old Operation had been seasonably performed. — The same Case also forcibly illustrates the Inutility of Local Compression as a Curative Measure of Axillary Aneurism. — Of Compression as a Curative Measure for Traumatic Aneurism in general. — The Results of the Treatment by Compression stated. — This Plan of Treatment not adapted to the Cure of Acute Traumatic Aneurism.

THIS formidable affection of the arterial system, the result of certain kinds of vascular injury, appears to have been well known to the ancient practitioners of the surgical art. Concerning it, Albucasis says, in substance, that when an artery is wounded and the skin heals over it, an aneurismal tumor is frequently the consequence. He also takes pains to say that the opening of such tumors by incision, especially if they are situated in the armpits, groins, and neck, would be a fatal mistake.[1] But Galen appears to have been the first writer in the order of time, to speak of traumatic aneurism. "He states that he has known cases in which an aneurism had been occasioned by a wound of the artery at the bend of the arm in venesection."[2] Aëtius observes, in effect, that aneurism may be produced in any part of the human body by the wounding of an artery, as when an unskillful surgeon, in opening a vein at the bend of the arm, opens an artery at the same time.[3]

Known to the ancient surgeons.

Galen the earliest writer on this subject.

In the preceding pages of this essay, five cases of traumatic aneurism have already been related. All of them resulted from external violence, but in each of them the wound of causation presented a different character. In the

Five cases already related in this Essay.

[1] Vide *Paulus Ægineta*, vol. ii. p. 312, London, 1846.
[2] *Op. cit.*, p. 311.
[3] *Op. cit.*, p. 311, 312.

first of them, following the order in which they were related, an aneurism of the anterior trunk of the internal iliac artery was produced by a punctured wound of that vessel inflicted by a bayonet thrust.[1]

First resulted from a punctured wound.

In the *second* instance an aneurism of the peroneal artery was produced by a lacerated wound of that artery, resulting from a fracture of the bones of the leg, and the tearing of that vessel by a sharp fragment of the fibula.[2]

From lacerated wound.

In the *third* instance an aneurism of the popliteal artery was produced by a gunshot wound, inflicted by a minie ball, which perforated that vessel, that is, passed through it from side to side.[3]

From gunshot wound.

In the *fourth* instance an aneurism of the popliteal artery was produced by an incised wound of that artery, inflicted by the point of a sabre, which divided that vessel completely.[4]

From incised wound.

In the *fifth* instance an aneurism of the brachial artery was produced by an incised wound, involving the external coat of that artery, and shaving off a portion of the same. The internal and middle coats protruded through the opening in the fibrous or external tunic, in such a way as to remind one, not a little, of the protrusion of femoral hernia.[5] This instance which, to say the least, is a remarkable one, is very clearly and concisely narrated by Dr. Smith.

Hernial aneurism.

We have, therefore, already had brought to our attention the subject of traumatic aneurism, produced by *punctured*, by *lacerated*, by *gunshot*, and by *incised wounds of arteries*, whereby their calibre was penetrated; and likewise the subject of traumatic aneurism occasioned by an incised wound of the external coat of a large artery, a portion of said coat having been shaved off by an amputating knife in such a way as to permit the internal and middle coats of the vessel to protrude through the opening in the external coat, and thus produce the so-called hernial aneurism.

Two principal varieties of traumatic aneurism are generally recognized among surgeons, namely, the *diffused* and the *circumscribed*.

Two principal varieties.

The *diffused* traumatic aneurism consists of a swelling occasioned by the extravasation of blood into some part of the body from a wounded artery, and is usually attended with more or less pulsation, thrill, and bruit, from the projection into it

Pathology of the diffused.

[1] Vide Case I. [2] Vide Case VII. [3] Vide Case X.
[4] Vide Case XXXIV. [5] Vide Case XXXV.

of blood in jets from the wounded vessel. This kind of tumor consists of effused blood, poured out into the deep connective tissue from, and communicating directly with, the canal of the wounded artery. Its extent is limited by the pressure of the surrounding parts, and by partially coagulated blood held in the meshes of the broken down connective tissue. Its boundary, which is ill defined, is composed partly of this coagulum, and partly of plastic matter, and has a constant tendency to spread from the pressure of the fluid blood, which continues to be projected into the centre of the aneurismal tumor. (Erichsen.)

Pathology of the circumscribed.

The *circumscribed* traumatic aneurism differs widely from the variety just mentioned, since it possesses a distinct sac, which is generally formed by a consolidation of the connective tissue through pressure, and through the exudation into it of plastic matter arising from the irritation to which the connective tissue is subjected. This form of aneurismal tumor is usually moderate in size, and tolerably firm in feel. It pulsates synchronously with the contractions of the heart, and almost always has a distinct bruit and thrill, which are suspended when the artery leading to it is sufficiently compressed, but they return again on the withdrawal of the compressing force.

Exceptional forms of circumscribed traumatic aneurism.

Besides this, which is the common form of *circumscribed* traumatic aneurism, two other forms are occasionally met with. One of them has already been presented to us in Case XXXV., and consists of the dilatation of the internal and middle coats of an artery, a portion of the external tunic having been shaved off with a sharp instrument in such a way as to permit it to take place; and the aneurismal sac is formed of the internal and middle coats of the vessel. In the other of these two rare varieties of *circumscribed* traumatic aneurism, the walls of the sac are formed from the external coat and the sheath of the artery. It usually arises from a small puncture of a large artery such as the axillary or the femoral. At first the bleeding is profuse; but being arrested by local pressure, both the external wound and the wound of the artery heal up. Afterwards, the cicatrix in the artery gradually yields, forming, at the end of weeks and months, a tumor which pulsates excentrically, with distinct bruit and thrill, and has all the symptoms that characterize an aneurism from disease. This variety of circumscribed aneurismal tumor possesses a distinct sac, formed by the dilatation of the cicatrix in the external coat and sheath of the artery, no blood being effused into the surrounding tissues. (Erichsen.)

The next case presents us with an interesting example of the common form of circumscribed traumatic aneurism. It was occasioned by a punctured wound of the *femoral artery*, which was inflicted with the point of a bayonet. It was related to the author by Professor Gouley.

CASE XXXVI. *Bayonet Wound involving Femoral Artery near its Commencement; Circumscribed Traumatic Aneurism, etc.* — Private Dennis McGarvey, Company I, 25th New York Volunteers, was admitted to the E Street U. S. Army General Hospital (Washington Infirmary), May 23, 1861. He had been accidentally wounded by a bayonet thrust in the right groin, about one hour before admission to hospital. The weapon entered horizontally, in a direction backwards and outwards, one inch below Poupart's ligament, and one eighth of an inch to the inner side of a line drawn from the middle of said ligament to the inner border of the patella.

Considerable hemorrhage occurred immediately after the wound was inflicted. It was arrested by local pressure. Dr. Gouley saw this patient, for the first time, four days after the accident, and found considerable tumefaction, with pain extending up to the inguinal region. The wound, three fourths of an inch in length, had healed by first intention. On palpation a distinct thrill could be felt, and that circumscribed for the space of not more than one inch and a half to the outside, and half an inch above and below the wound. A bellows murmur was distinctly heard on applying the ear lightly over the space above described.

Treatment. — Horizontal posture, and the local application of an evaporating lotion of lead and opium continued for a week.

June 11. — The patient felt so well that he insisted on joining his regiment, and accordingly was discharged from the hospital.

The day previous to his discharge he was again examined with the following result: Small circumscribed tumor having the size of an English walnut, and presenting the same physical signs as already noted. Compression of the femoral artery above it arrests pulsation, thrill, and bellows murmur, and causes it to diminish in size and become soft.

The patient promised to report himself if the tumor should increase in size, but nothing was heard of him afterwards.

Comments. — This case serves well to illustrate the method in which a circumscribed traumatic aneurism is not unfrequently formed. Some important artery happens to be punctured with a narrow-bladed or slender instrument. Arterial hemorrhage immediately ensues. It is arrested by compression. The wound of the integuments unites by adhesion, and probably while the compression is still applied. Not so, however, with the orifice in the wounded artery. It does not heal, and, under the

How sometimes formed.

circumstances, it cannot close spontaneously even for a brief period. On the contrary, the blood continues to be projected from it with each pulsation, and sooner or later, according to the nature of the surrounding parts and other circumstances, an aneurismal swelling of considerable size is formed. The external bleeding has ceased because the external orifice of the wound is closed, but the internal bleeding continues because the internal orifice — the aperture in the walls of the artery — is not closed. Although the wound of the integuments and the superficial parts is healed, the wound of the artery is not healed. Hence, in dealing with cases belonging to this category, and, indeed, with all cases of traumatic aneurism, it is well for the surgeon always to keep in view the fact that he is in reality dealing with a wounded artery, that the external bleeding is temporarily restrained by an exceptional condition of the superficial parts, that the aperture in the vessel cannot become closed without the assistance of surgical art, and that the whole interest and danger of the case arise from the arterial wound. By such considerations we are enabled to perceive the reasons why punctured wounds of arteries are more liable to be followed by traumatic aneurism than the other forms of vascular injury, and why they prove so dangerous and troublesome.

The following case presents us with an instance in which the *axillary artery* was severed by a carbine-bullet. The wound did well for a period of three weeks, when traumatic aneurism suddenly supervened. It occurred in the author's practice.

Case XXXVII. *Gunshot Wound dividing the Axillary Artery, and injuring the Brachial Plexus of Nerves, of the Left Side; Circumscribed Traumatic Aneurism occurring on the Twenty-first Day; Ligature of the Subclavian external to the Scalenus; Death Forty-six Days afterwards from Exhaustion, produced by Secondary Hemorrhage and Suppuration.*— Captain John F. Jordan, Company B, 13th Virginia Cavalry (Confederate), aged 31 years, and of sound constitution, was admitted to Stanton U. S. Army General Hospital, June 23, 1863. He had been wounded two days before (June 21), in action near Middleburgh, Va., by a shot from a carbine. The bullet, which, by the way, was conical in shape, penetrated the pectoralis major muscle of the left side, at a point on a level with the axillary artery, and about one and one half inches from the margin of the armpit, passed directly backwards beneath the shoulder, wounding the axillary artery, together with the brachial plexus of nerves, and escaped behind. Patient said he lost a great deal of blood immediately after the wound was inflicted, so much indeed that he fainted, when the hemorrhage ceased of itself, and did not return.

CHAPTER FOURTH.

ON TRAUMATIC ANEURISM.

This Accident was well known to the Ancient Surgeons. — Galen was the Earliest Writer on this Subject. — Five Cases of Traumatic Aneurism have already been related in this Essay. — The First resulted from a Punctured Wound. — The Second from a Lacerated Wound. — The Third from a Gunshot Wound. — The Fourth from an Incised Wound. — The Fifth was an Example of Hernial Aneurism. — Two Principal Varieties of Traumatic Aneurism recognized: 1. the *Diffused*; 2. the *Circumscribed*. — Pathology of the Diffused Variety. — Pathology of the Circumscribed Variety. — Two Exceptional Forms of the Circumscribed Variety also mentioned. — An Illustrative Case of Circumscribed Traumatic Aneurism of the Femoral Artery produced by a Bayonet Wound, contributed by Professor Gouley. — The Way in which this Variety of Aneurism is not unfrequently produced. — Traumatic Aneurism is, in Reality, a Variety of Arterial Wound in which the External but not the Internal Bleeding has ceased. — A Case in which the Axillary Artery was severed by a Carbine-ball; Circumscribed Traumatic Aneurism appeared on the Twenty-first Day; Ligature of the Subclavian; Death Forty-six Days afterwards from Exhaustion, produced by Secondary Hemorrhage and Suppuration. — *Comments.* — Concerning Hemorrhage from Wounded Arteries. — On the Means by which the Bleeding stops of itself when Large Arteries are Severed by Gunshot Projectiles. — Why Arteries are more liable to bleed when partially than when completely divided. — Concerning the Surgical Treatment of Primary Hemorrhage. — On the Causes of the Aneurismal Murmur and Thrill. — Why the Murmur and Thrill are sometimes not present. — Pathology of the Aneurismal Swelling in the Case just related. — Pathology of the Secondary Hemorrhage which occurred in the same Case. — It did not occur from the Distal End of the Severed Artery. — It did occur from the Proximal End through Reflux of Blood in the Branches of the Axillary when the Collateral Circulation got well established. — The Old Operation should have been performed in this Case. — The Reasons why stated. — These Views are corroborated by Sir Charles Bell's Case, which is here related. — Surgical Treatment of Traumatic Aneurism in general. — The Ancient Surgeons were acquainted with Excellent Methods of treating this Lesion. — Galen, Aëtius, and Paulus Ægineta referred to. — Of the Operation of Antyllus, now frequently called "the Old Operation." — Albucasis and Haly Abbas also referred to. — Treatment of Diffused Traumatic Aneurism. — The Old Operation generally to be preferred. — Treatment of Circumscribed Traumatic Aneurism. — Objections to the Plan of Hunter in such Cases. — It may fail through inducing Consecutive Gangrene or Secondary Hemorrhage. — The Old Operation less likely to be followed by these Disasters. — The same Subject continued. — Mr. Syme deserves much credit for reviving the Old Operation. — An Illustrative Case in which the Old Operation was performed with an Excellent Result. — Immense Pouch-shaped Aneurism of the Femoral Artery, produced by Gunshot Injury; treated by tying the Vessel on both the Proximal and the Distal Side of the Orifice with a Good Result. — Concerning Distal Hemorrhage in this Case. — Description of the Aneurismal Sac. — Progress of the Case after the Operation very satisfactory. — How the Difficulties attending the Performance of the Old Operation in Cases such as the Foregoing may be obviated. — Rules laid down. — Additional Remarks concerning the Treatment of Traumatic Aneurism of the Axillary Artery. — The Plan of Treatment should be adapted to meet the Peculiarities of Traumatic Aneurism in Special Cases. — A Case of Traumatic Aneurism of the Femoral Artery occasioned by Gunshot Injury; Secondary Hemorrhage occurred Several Times; cured finally by opening the Sac and tying the Artery both above and below the Place of Injury. — We generally prefer the Old Operation to that of Hunter and Anel, because it is more likely to prove successful. —

Diagnosis; Circumscribed Traumatic Aneurism of the Axillary Artery. — From the entire absence of pulsation in all the arteries beyond the aneurism, which existed even at the time of admission to hospital, and the complete want of thrill and bruit in the aneurism itself, we believed that the aneurism had been developed from the proximal end of the severed artery, and that opinion was strengthened by the fact that the swelling had not expanded outwards and downwards into the armpit, where there was but little in the anatomical structure of the parts to obstruct its growth, any more rapidly than it had done in another direction, where it was covered over and bound down by the pectoral muscles. The swelling had expanded so equally in all directions, that the scar of the anterior wound still remained exactly over the centre of the tumor, as when we first saw it.

The aneurism was so distinctly circumscribed, that although its origin was traumatic, it was deemed advisable to attempt a cure of it by the Hunterian method. As there was not sufficient space to secure the artery below the clavicle without opening the sac, I proceeded to tie the left subclavian artery external to the scalenus, on the afternoon of that day (July 14). The patient being under sulphuric ether, that operation was performed without difficulty by the ordinary method. On tightening the ligature the tumor ceased to pulsate, shrunk a good deal, and became soft.

The left arm was directed to be wrapped in cotton wool, and to be kept warm by the further aid of bottles of warm water, to be renewed from time to time as occasion might require. A full dose of morphia was prescribed. He was enjoined to preserve the recumbent posture, and to avoid exertion of every kind. A milk diet was allowed.

July 15. — Patient had a comfortable night; temperature of arm not diminished; discontinued the warm water.

July 16. — Patient doing well in every respect; arm warm; color thereof good; discontinued the cotton wool.

July 17. — Bowels being confined, he took magnes. sulph. ℥i.

July 19. — Aneurismal sac opened spontaneously last night through the anterior scar of the gunshot wound, and discharged two or three ounces of very dark-colored blood, mixed with pus. Suppuration of the sac had been threatened ever since the day after the operation. He was allowed a full diet.

July 20. — A moderate discharge of old blood and pus, accompanied with a gradual diminution in the size of the aneurism, and but a moderate degree of inflammation of the sac continued on this and several days following, the patient's general condition being unexceptionable all the while.

July 27. — The aneurismal swelling had entirely disappeared; suppuration of the sac, moderate in quantity, still continued, the pus being of a good quality.

August 1. — *The ligature separated and was removed to-day, without the occurrence of hemorrhage or any other difficulty;* discharge from sac good in quality and steadily diminishing in quantity; discovered some excoriation at the inner side of the left elbow, occasioned probably by pressure, the patient having followed very closely the injunction to keep as still as possible in the recumbent posture; directed a stimulating plaster to be applied, and the pressure to be removed to other situations by arranging pillows.

August 5. — Discharge from sac had subsided to a small quantity of healthy pus, and the orifice was manifestly contracting. We hoped that adhesion of the sac was taking place. Patient's condition seemed to be favorable in every respect, except that he had been losing flesh rapidly for several days without obvious cause. For want of any other reason, we attributed it to the extreme heat of the weather, the temperature both day and night having been unprecedented ever since July 25th, the mercury at midday ranging from 90° to 100° in the shade, and seldom falling below 80° at night.

August 6. — A profuse flow of blood from the sac came on this morning without warning; the loss of blood being so rapid as to threaten speedy death. The officer of the day was close at hand, and stopped the bleeding by injecting about one ounce of liquor ferri persulph. into the bottom of the sac, through a female catheter, introduced for the purpose. The hemorrhage ceased immediately. We had been emboldened to use the persulphate of iron freely in this way, because we had a few weeks before (June 22) stopped a troublesome secondary flow, in alarming quantity, of arterial blood from the cavity of a large abscess, associated with gunshot fracture of the right thigh, by injecting about two drachms of liquor ferri persulph. through a catheter, carried into the neighborhood of the supposed source of the hemorrhage, a branch of the profunda artery, and no unpleasant effect of any kind followed it. Again, about the same time, we had been troubled to manage a case of general oozing of blood from the cut surface of a thigh, amputated secondarily for gunshot injury. After trying exposure to the air, ice water, and even ice, without effect, we stopped this bleeding immediately by covering the end of the stump with pledgets of lint soaked in liquor ferri persulph. Aside from pretty severe pain, which soon subsided, no unpleasant consequence of any kind followed. We did not discover any evidence of even the feeblest action as an escharotic, and indeed have since thought that the case progressed better than other amputations of the same class.

In consequence of the secondary hemorrhage and the efforts to repress it, the aneurismal sac became filled up again to the original size.

August 10. — Another severe hemorrhage occurred from the same orifice; it was readily stopped by again injecting persulphate of iron in solution.

August 11. — Profuse hemorrhage occurred to-day through the opening of the posterior orifice made by the bullet, after it had been healed for more than a month. This bleeding was also suppressed immediately by injecting liquor ferri persulph. through a catheter. After this there was no more hemorrhage. During the next few days he seemed to rally from the depression produced by these repeated losses of blood. He was ordered to have wine, and anything in the line of supporting treatment that he would take.

August 18. — The aneurismal sac has again suppurated, and there is a profuse discharge of dark-colored and very offensive pus.

August 25. — Patient failing rapidly; suppuration very profuse and extremely offensive in character.

August 29. — He died worn out with the suppuration and the hemorrhages forty-six days after the operation, and twenty-eight days after the ligature came away.

Autopsy eighteen hours after death: Emaciation extreme; rigor mortis moderate; a large elongated cavity, with ragged dark-colored walls, occupies the original seat of the aneurism, and extends beyond it outwards into the axilla; the axillary artery is found to have been severed obliquely by the bullet about one and one half inches above its termination in the brachial; the divided extremities are separated widely apart, (to the extent of about three inches); the distal end appears to have been pushed away from the proximal end, either by the original aneurism, or the subsequent hemorrhages and suppuration; the proximal end is oblique and closed, while the bruised and lacerated portion of it appears about to be cast off by the ulcerative process, as a distinct line of demarcation has been formed; the distal end is oblique and unclosed, but the calibre of the artery is contracted down to about a line in diameter, and it is blocked up by a coagulum three eighths of an inch long; the branches of the axillary given off above the point of injury, especially the superior thoracic and the acromial thoracic are much enlarged; the axillary vein is greatly diminished in size about the track of the bullet, but it is still pervious; the brachial plexus of nerves was also wounded by the bullet, all the trunks being cut off except that of the musculo-spiral and circumflex nerves. The extremities of the divided trunks (proximal) were somewhat bulbous.

At the seat of the operation the wound, which at one time was nearly closed, is now open quite down to the artery at the point of ligation, the new granulations having been reabsorbed to that extent, but the artery for a distance on each side thereof is surrounded by a dense mass of new connective tissue, so thick and dense as to make it a little difficult to get at and remove the specimen without injury. On the proximal side of the ligature the vessel is blocked up to a distance of about five eighths of an inch; on the other side of the ligature it is blocked up to the extent of about two eighths of an inch.

In the cavity of the thorax we find old pleuritic adhesions on both sides, and old tuberculous cicatrices at the apex of each lung; but both lungs are now entirely free from tuberculous deposits: abdomen not opened.

The following specimens belonging to this case were sent to the Army Medical Museum, Sept. 10, 1863: —

1st. The ligature.

2d. A piece of the artery extending from a distance within the seat of ligature down to the point of severance by the bullet, showing effects of ligature, etc.

3d. A piece of the artery from the distal side of the wound, showing its diminished calibre, obstruction, etc.

4th. The brachial plexus of nerves, showing the trunks which were severed by the bullet.

Comments. — This case deserves more than a passing notice. It illustrates several surgical themes of great interest, and therefore will repay attentive study. In the first place it invites our attention to the subject of hemorrhage, and especially to that form of it which is occasioned by wounds of the larger arteries. The principal danger attending the wounds of all arteries, arises from the loss of blood; and the greater danger which attends wounds of the larger arteries, is due to the fact that the loss of blood from them may be so rapid as to destroy life before surgical assistance can be obtained. Incised wounds severing any of the larger arteries are always speedily fatal unless the hemorrhage chances to be arrested by art. Thus, the suicide cuts his throat so as to sever the carotid artery, or gashes his thigh, so as to sever the femoral artery, or the homicide stabs his victim in such a way as to cut across the axillary artery, and he bleeds to death in from five to ten minutes, unless the hemorrhage be retarded or arrested by extraneous aid. In all cases nature unassisted is powerless to prevent a fatal result.

Hemorrhage from wounded arteries.

But such an issue does not necessarily follow gunshot severance of an artery belonging to the class above mentioned, as the history of Jordan's case abundantly proves. The autopsy showed that the carbine-shot had divided the axillary artery completely, and the patient's statement showed that the hemorrhage from the wound, which was very profuse at the outset, soon ceased spontaneously, and did not recur. Moreover, the loss of blood was not so great as to be noticeable in his appearance two days afterwards, when he was admitted to hospital. Now it becomes a matter of surgical interest to inquire into the reason why

Spontaneous arrest of hemorrhage.

nature unaided can stop the hemorrhage from a large artery, severed by a gunshot, and cannot stop it in case of clean division by a cutting instrument. The foregoing case will, I think, if studied closely, afford a satisfactory explanation. The carbine-shot bruised and lacerated the coats of the artery as it passed athwart them: the roughly divided arterial tunics retracted within the sheath, and contracted upon themselves immediately, by virtue of the elasticity of the middle coat, and thus a lodgment for clot was formed in the bruised extremity of the artery. But while this was taking place the patient lost blood so rapidly as to become faint (he said he fainted), whereby the tendency of the blood to coagulate (coagulability) was increased; the volume and firmness of the clot being proportionately increased, and the force of the circulation diminished all at the same time. In this way nature unassisted plugged up the severed artery with a coagulum, so as to stop the effusion of blood speedily. It appears, on the other hand, that in case of the severance of a large artery by an incised wound, the hemorrhage does not cease spontaneously, for want of a place of lodgment for a coagulum sufficient to stop up effectually the bleeding orifice: and moreover, that spontaneous occlusion of an incised wound of an artery, by coagulum, is never effectual to stop the hemorrhage, except the artery be a small one, such as the anterior temporal (branch), and even then complete division is essential to success, as observation has abundantly shown. Observation has also shown that the greater the amount of the contusion and laceration inflicted upon an artery, the smaller is the quantity of hemorrhage, other things being equal; or, in other words, that the more an artery is bruised or torn, the more readily is a lodgment afforded for such a coagulum as will restrain bleeding: vide cases of limbs torn off by cannon-shot and machinery, scattered everywhere through the annals of modern surgery.

There is another interesting feature connected with the topic under consideration. This man was struck by a carbine-shot, fired at short range, the projectile having therefore the maximum of velocity, or nearly so, and consequently the extremities of the severed artery were contused and lacerated proportionably less than they would have been by a similar bullet moving at a slower rate of speed. This view is corroborated by the appearance of the wounds of entrance and exit, and by the cleanness with which the trunks of the brachial plexus were divided. When exposed at the autopsy, they looked as if they might have been cut off with a knife, instead of a gunshot. It is therefore clear that the artery

was not severed under circumstances the most favorable for affording a lodgment to the clot, and for the spontaneous arrest of the hemorrhage. Now, it becomes highly probable that the result achieved by nature, unaided, in this case, is not at all an exceptional one; and, viewed in this light, the examples of similar wounds of the femoral and other arteries, not fatal from primary hemorrhage, that have already been related in this essay, lose the surprising features of their character, and become simply illustrations of what nature is capable of accomplishing under similar circumstances.

Hemorrhage from partially divided arteries.

These remarks apply only to cases of hemorrhage occurring from *completely divided arteries*. If, on the other hand, the artery be but *partially divided* (for example, to the extent of one fourth or one half its circumference), the hemorrhage becomes much more dangerous in character; for, retraction within the sheath being impossible on the part of the arterial tunics, the orifice in the artery gapes open, and assumes a round or oval shape, according to the extent to which the division has been carried, which allows a free escape of the blood, and presents no facilities for plugging up the bleeding orifice with an efficient coagulum.

In this way, hemorrhage from small arteries, when but partially divided, may become troublesome to stanch, and even fatal to life, if the exact character of the wound of the artery is not recognized in season. This statement obtains whether the wound be incised or gunshot, in both cases alike. I have seen instances of obstinate primary hemorrhage, occurring in connection with partial division, by musket-shot, of such arteries as the radial, the ulnar, and the anterior tibial. Now, either one of these arteries would not have bled much, if at all, provided it had been completely divided by the bullet in the first instance.

Surgical treatment of primary hemorrhage.

With regard to the *surgical treatment of hemorrhage* from a small artery partially divided by a gunshot, I believe, from observation, that the best course to pursue, is in case the artery be a small one, first to try the hemostatic effect of pressure, evenly and carefully applied at the seat of injury to the vessel; and, if the bleeding continue or recur, then enlarge the wound and tie the artery on both the proximal and distal sides of the orifice. But if the bleeding artery be a large one, there is then no time to be lost in trying pressure. The track of the bullet should, without delay, be dilated by incision, so as to expose the wounded vessel, which should then be tied, both on the proximal and distal side of the aperture in it, after the method recom-

mended by John Bell, and earnestly enjoined by Guthrie. For such cases, I believe that any treatment less thorough than this, even when promptly applied, is inefficient and reprehensible, because it exposes the patient's life to unnecessary danger. If the bullet pass through a limb in a very oblique direction, wounding its principal artery, it may be deemed advisable to cut directly down upon the vessel, at the seat of injury to it, instead of dilating the track of the bullet; but such a case has never come under my observation.[1] I can, however, readily conceive that it may occur; and if it should, I would have no hesitation in cutting directly down upon the vessel and securing it by two ligatures, one placed on the proximal and the other on the distal side of the wound in it, although the original injury would thus be complicated with an additional wound of operation; for simple incised wounds of the extremities, even when very large, almost always do well. Next to the application of ligatures to both the proximal and distal sides of wounds of arteries, I consider it a matter highest in importance, in all cases of hemorrhage from a probable lesion of a large artery, to *dilate the wound without delay and secure the bleeding vessel by ligature.* If reliance be placed upon plugging up the track of the bullet, and upon applying pressure on the outside, and such treatment be put in practice where a large artery has been wounded, the patient will be likely to die, sooner or later, exhausted by repeated hemorrhages, and infiltration of the parts bordering upon the wound with blood, while, at the same time, if the hemorrhage had been treated by tying the artery on the principles above advocated, recovery would have taken place without difficulty.

Aneurismal Murmur and Thrill. — Again, this case is remarkable in that the aneurism, which made its appearance July 12th, was developed from the *extremity* of a severed artery. I certainly have never seen, and do not remember ever to have heard or read, of but one other case,[2] where a pulsating tumor filled with blood, and communicating with an artery, was developed otherwise than in the continuity of the blood-vessel. This terminal development of the aneurism probably accounts for the absence of the aneurismal bruit, and the aneurismal thrill, as this origin does not, under ordinary circumstances, seem to admit of such disturbance of the undulations in the circulating

Causes of the aneurismal murmur and thrill.

[1] This operative procedure was practiced in the case of Williams, No. XXIX., which, however, was an instance of incised wound involving the brachial artery.

[2] Vide Case of Repasses, No. XXXIV.

blood as to cause them to recoil upon each other; thus destroying the rhythm of the undulations, and producing discords (jarring vibrations), cognizable by the senses of touch and hearing. On the other hand, if an aneurism of the variety called fusiform[1] be developed in the continuity of an artery, the rough, warty, and granular lining of the expanded vessel appears to be capable of producing such a disturbance in the wave-like current of the passing blood as to grate harshly on the touch and ear. But, in order for this to take place, it is necessary that the blood should pass beyond the aneurism through a continuous tube, otherwise the current would be stopped in the aneurism, or would not move with sufficient velocity into and through the aneurism to produce a thrill, or a rasping sound.

In the variety of spontaneous aneurism denominated sacculated,[2] the murmur and thrill are generally quite as well marked as in the variety denominated fusiform. But here the disturbance in the undulations of the circulating blood is produced in a different manner. In the case of the sacculated aneurism, at each contraction of the heart a portion of the blood contained in the affected artery is forced out through the hole, aperture, or opening in its side, into the aneurismal pouch connected with it, and thus the rhythm of the undulations is effectually broken at the point of communication between the vessel and the aneurismal pouch, and likewise through the pouch itself. The undulations are broken, not by the roughened lining of the expanded artery, but by the outflow of a stream of blood from the side of the vessel, at a right angle with the general direction of the current of the blood, into the aneurismal pouch.

Inasmuch as the structure and shape of no two aneurisms is exactly alike, it follows that in no two cases are the undulations of the circulating blood disturbed in precisely the same manner, and to precisely the same extent. And furthermore, that in no two cases are the tones of the aneurismal bruit precisely the same. In fact, clinical observation has shown not only that this bruit is never exactly the same in different cases, but that it exhibits a very wide range as to tone, varying from a harsh rasping sound on the one hand, to a faint bellows murmur on the other.

Why the murmur and thrill are sometimes not present.

Besides, on account of the abrupt termination of the current of the circulating blood in the aneurismal sac, from want of continuity in the vessel beyond it, the aneu-

[1] We follow Mr. Erichsen's classification.

[2] Still following Mr. Erichsen's classification.

rismal thrill and the aneurismal bruit may also be absent, because the sac is filled up with coagulated blood, so as to take part no longer in the undulations communicated by the heart to the whole vascular system. This happens most frequently in the variety of spontaneous aneurism called false (sacculated), and then the tumor continues to pulsate, not on account of any movement in its contents, but on account of the impulse communicated to it, externally, from the artery. But the aneurismal bruit and thrill were not absent in Jordan's case, because the sac was filled with coagulated blood, for, on stopping the flow of blood into it, by compressing the subclavian artery over the first rib, it became much shrunken and soft in a little time, and on withdrawing the compression it gradually became filled up to the original size and tense again, thus showing conclusively the liquid character of its contents.

Again, a narrowness of the aperture in the artery did not cause the aneurismal bruit and thrill to be absent, for the tumor pulsated strongly and expansively, outwards in various directions from its centre, which decidedly implied that free communication existed between the cavity of the aneurism and the artery. Furthermore, I think that the blood would be likely to flow into an aneurism developed from the end of a divided artery with a noise (bruit), synchronous with the contractions of the heart, if the vessel were suddenly narrowed, constricted, or otherwise obstructed at its point of termination in the aneurism, for such obstruction would disturb the equability of the flow of the blood past it, to greater or less extent, according to the amount of the obstruction, and would, to the same extent, disturb the wave-like motion of the blood, at and beyond the point of obstruction. It, therefore, appears to be philosophical to infer that in the case of Jordan, the extremity of the axillary artery, from which the aneurism was developed, was not obstructed in any way of importance.

Pathology. — The pathological history of the aneurism was probably as follows: its development commenced by the yielding of the yet imperfectly organized plug or scar, at the end of the cardiac portion of the severed artery. As the blood pushed the scar gradually before it out in every direction, the connective tissue, already more or less thickened by inflammatory exudation in and about the track of the bullet, was gathered together by degrees before it, so as to form a sac of considerable thickness and strength. As the tumor grew larger and spread beyond the limits of the inflammatory exudation, the

Pathology of the aneurismal swelling in the case last related.

uninjured connective tissue also was progressively condensed on the exterior of the forming sac, and thus it happened that the walls of the sac remained strong, and retained about the same thickness, notwithstanding the comparatively rapid development of the swelling.

We may state in a general way that the walls of the aneurism were formed by the coalescence of cellular or connective tissue, a part of which had been more or less consolidated by plastic exudation thrown out in its meshes. The singularly rounded shape, and distinctly circumscribed character of the swelling, were probably due to the thickening of the connective tissue in the gunshot wound, more especially in the neighborhood of the ends of the severed artery.

Connective tissue coalescing in this way to wall in and circumscribe a gradual outflow of blood from an artery, or to form an envelope for a chronic swelling of any kind, generally exhibits but little tendency to ulceration, and, therefore, I would not have been inclined to hasten to operate, had it not been that the scar in the track of the bullet was likely to give way in a short time, on account of the constant outward pressure of the blood in the aneurism.

Pathology of the secondary hemorrhage which occurred.

Modus Operandi of the After-Bleeding — The *pathology* of the *secondary hemorrhage*, which occurred in Jordan's case, is also an interesting subject, and next demands our attention. Did the blood escape from the distal or the proximal end of the severed artery? It is a fact well established by observation, that secondary hemorrhage from wounded arteries generally takes place from the distal side of the wound, because of the feeble adhesion and the imperfect closure of the artery on that side of the wound in it; and when the collateral circulation comes to be sufficiently established, the blood flowing backward in the distal portion of the vessel, readily overcomes the feeble union at the seat of injury, and makes its escape therefrom. It is this inability on the part of the reparative process, unaided by art, to securely close the artery on the distal side of the wound, which makes the application of a distal ligature a matter of so much importance in all cases of wounds involving arteries of magnitude. But the secondary bleeding in the case under consideration, probably did not take place from the distal end of the severed artery. For, at the autopsy, this part of the vessel was found to be very much contracted, its calibre being reduced to about a line in diameter, and this extreme degree of con-

Did not occur from the distal end.

traction existed not only at the end, but continued as far as the vessel was examined, which was a distance of two or three inches. Now, the distal part of the artery thus diminished in size, was entirely too small to supply the quantity of blood which was poured out on either of the three occasions when secondary hemorrhage occurred. Moreover, the shrunken vessel was blocked up by a coagulum for a distance of nearly half an inch, commencing a little way within its wounded extremity. For these two reasons I think that the secondary bleeding could not have taken place from the distal end of the severed artery.

From the proximal end, through reflux of blood.

But, at the autopsy, we found that the proximal portion of the vessel was not diminished in size, and what was still more important, that its branches, such as the thoracica acromialis and the superior and the inferior thoracics, were very much enlarged. Their increased size was apparently connected with the establishment of the collateral circulation, and on that account they probably performed an important part in the production of the secondary hemorrhage. The initial one of the three secondary bleedings occurred, in all probability, from the proximal end of the artery, and in this way: the collateral circulation having been established, the blood flowed backwards, through the branches above mentioned, into the part of the axillary artery embraced between the seat of the ligature and the point of division by the bullet, with sufficient force to overcome the adhesions, which had again closed the proximal end of the vessel, subsequent to the deligation of the subclavian artery. Thus, these adhesions being overcome, the blood found its way readily into the aneurismal sac, which was not yet obliterated, and escaped externally through the opening into the sac which was not yet closed.

One of the subsequent hemorrhages may have been occasioned by ulceration of the subscapular artery; for, while making the autopsy, I noticed that this vessel was wanting, having apparently been destroyed by extension of the ulcerative process from the suppurating sac.

The old operation should have been performed.

It is probable that the employment of the old operation is more essential to the ultimate recovery of the patient from traumatic aneurism of the *axillary artery*, than from the same lesion involving almost any other artery of similar magnitude in the whole body. This necessity of ligating a wounded axillary artery at the seat of injury to it, always, not even making an exception when a circumscribed traumatic aneurism is the subject of treatment, is occasioned by the intimate vascular relations

which exist between this vessel and the neighboring parts. It will be remembered that the great artery of the upper extremity, while passing outwards behind the pectoral muscles, and beneath the clavicle and the shoulder, gives off no less than six branches of considerable size, between the inferior border of the first rib and the fold of the armpit, all within the space of a few inches. These branches inosculate freely below the axillary region, both in front and externally, with branches of the internal mammary and intercostal arteries, and also above and behind that region with branches of the supra and posterior scapular arteries. It will thus be perceived that, in the case of an aneurism of the axillary artery, treated by ligature of the subclavian in the third part of its course, or even by ligature of the axillary itself near its commencement, if perchance the sac should suppurate and its contents be discharged externally, secondary hemorrhage of a dangerous character is almost sure to follow, as soon as the collateral circulation is sufficiently established; and even then the bleeding may not take place from the distal portion of the vessel, as usually happens in cases of secondary hemorrhage produced by traumatic lesion of arteries, but from the proximal portion of the vessel, as happened in Jordan's case. From these considerations it seems to me that, without doubt, the most rational and effectual way of preventing such secondary hemorrhage is to secure the vessel by ligatures applied to the seat of the original injury, one on each side of it, instead of tying the artery at some distant point.[1]

Furthermore, statistics[2] show that the sac is much more liable to suppurate in cases of aneurism of the axillary artery than it is in cases of the same disease involving any other vessel. Now,

[1] In this connection Sir Charles Bell's case has peculiar significance: — "A girl had had her arm torn off near the shoulder by machinery. There was no bleeding, nor could the trunk of the artery be seen. As the arm had been almost fairly amputated by the machine, it was unnecessary to do more than to make the edges of the wound even, and bring them together. As the axillary artery had not been tied, the patient was carefully watched. In the course of a few days hemorrhage did come on, and the surgeon very properly tied the artery below the clavicle. The bleeding from the stump immediately stopped, and everything went on well for several days; the stump became clean, and was granulating, when *a second violent hemorrhage took place from it.* The surgeon did not reach the hospital till the patient had lost a considerable quantity of blood. He immediately tore open the stump, which was already partly united, and *now he saw the blood issuing from the main artery.* He secured it; but the patient sunk next day.

Views corroborated by Sir Charles Bell's case.

"On dissection, and by injecting the vessels, it was shown that *the artery, where it had been tied below the cavicle, was obliterated,* and that *the blood had passed round by the supra-scapular branch of the inferior thyroid* (thyroid axis?) *from the portion of the subclavian artery above the ligature into the part below.*" (Vide *Diseases and Injuries of Arteries* pp. 265, 266.)

In this case the operation which should have been performed at the outset, and which would have saved the patient, was employed too late.

[2] *Erichsen's Surgery*, pp. 557, 558.

without stopping to inquire into the cause of this special tendency to suppuration of the sac, and consequent secondary hemorrhage, I think that the existence of such a tendency makes it still more the duty of the surgeon to tie the vessel both proximally and distally at the seat of injury in *all cases of traumatic aneurism of the axillary artery;* and I believe that an attempt should be made to secure the vessel in this way in all such cases, unless it is certain that the arterial tunics are softened, expanded, or otherwise metamorphosed, so that they will not hold a ligature or permit the application of one at the seat of injury to the artery, and this can only happen when the aneurism, growing but slowly, has existed a long time, or when there was preëxisting disease of the coats of the vessel at the point of injury.

Surgical Treatment of Traumatic Aneurism. — It has already been shown that the ancient surgeons were not unacquainted with at least some of the means by which traumatic aneurism is produced. It may be stated, further, that they were not unacquainted with excellent methods of treating this formidable lesion, at least so far as the arteries of the upper extremity and the leg are concerned. Galen relates a case of traumatic aneurism at the bend of the arm, in which a cure was accomplished by the application of a sponge with bandages.[1] This is probably the first case on record in which a traumatic aneurism was cured by local pressure. Aëtius declares, with regard to the treatment, that aneurism in the neck and head ought not to be interfered with; but when the disease arises at the bend of the arm, the artery should be exposed by incision, three or four fingers' breadth below the armpit, tied with two ligatures, and divided between them. The swelling at the bend of the arm may then be opened without any fear of hemorrhage, its contents removed, two ligatures applied, one above and the other below it, and it may then be divided between them.[2] The operation of Antyllus, which is now frequently called "the old operation," consisted in tying the artery both above and below the aneurismal tumor, and then evacuating its contents. Antyllus states, "that when the disease occurs in the hams, groin, or neck, it is dangerous to meddle with it; but that when seated in the extremities it is easily cured." All the cases in which he had known the artery to be opened in venesection, had terminated in aneurism, except one which was cured by compression.[3] Albu-

The ancient surgeons were acquainted with excellent methods of treating this lesion.

Operation of *Antyllus*, called "the old operation."

[1] Vide *Paulus Ægineta*, vol. ii. p. 311. [2] *Op. cit.*, p. 311, 312. [3] *Op. cit.*, p. 313.

casis recommends that spontaneous aneurism should be treated with the proximal and distal ligatures, the part between the two ligatures divided, and the blood evacuated. Applications promotive of suppuration should then be made until the ligatures come away.[1] Haly Abbas directs us, when an artery has been wounded in venesection, to expose the vessel at the place of injury by dissection, and, having applied a thread on each side of the wound, to divide the artery in the middle. When an aneurism takes place, he recommends a plan of treatment similar to that advised by Albucasis.[2]

The commentator observes that "it will be perceived from the foregoing account of the practice recommended by Aëtius, that the ancient surgeons were aware of the advantages of securing the artery above the seat of the aneurism, as practiced by the late Mr. Hunter, and that they actually had recourse to two ligatures in the manner directed by Mr. Abernethy; but that they afterwards opened the tumor and evacuated its contents, not having yet learned from experience to trust to the absorbent powers of the system. It will likewise be remarked that carotid, axillary, and inguinal aneurisms were, in ancient times, abandoned as incurable; so that modern surgery may undoubtedly boast of having so far improved upon the practice of the Greeks and Arabians." [3]

After the lapse of many centuries the old operation, or that of Antyllus, continues to be preferable to all others, even at this day, in the treatment of most forms of traumatic aneurism. In the following case, that operation was employed with a degree of success which was very gratifying to both patient and surgeon.

When the old operation is to be preferred.

But before we proceed to narrate this case, it is, perhaps, advisable to make some additional observations upon the *surgical treatment* appropriate for *traumatic* aneurism. As already stated, all cases of this affection are classified under the one or the other of two heads: 1st, *diffused traumatic aneurism*, and 2d, *circumscribed traumatic aneurism*. With regard to the *diffused* form, there appears to be no doubt as to the best course to be pursued. The artery should be exposed at the seat of injury by an incision sufficiently free for the purpose, and a ligature should be applied to both the proximal and the distal side of the bleeding orifice, or, in other words, the old operation for aneurism should be performed. It should be treated on precisely the same principles as if the artery were wounded and bleeding at the time. For, in the one case, the blood flows out through an

[1] Vide *Paulus Ægineta*, p. 313. [2] *Op. cit.*, p. 313. [3] *Op. cit.*, p. 314.

external opening, and in the other case it escapes into the connective tissue, where it accumulates for want of an external opening through which to escape; but so far as the lesion of the artery is concerned, there is no essential difference between them. After securing the vessel by ligatures, both proximal and distal, the cavity of the diffused aneurism should be thoroughly explored, and all the coagulated blood should be carefully removed, otherwise offensive and tedious suppuration will be likely to occur.

Treatment of circumscribed traumatic aneurism.

With regard to the treatment of *circumscribed* traumatic aneurism, there is, however, more room for difference of opinion. This disease presents the same general features as the false variety of the spontaneous aneurism, and in many instances, especially those cases which progress but slowly, closely resembles it in every respect, except that the origin is traumatic, and that no arterial tunic enters into the formation of the sac. In rare instances, however, certain of the arterial coats may assist in the formation of the sac, a circumstance which has already been pointed out, and when it is present renders the resemblance still more striking.

This close similarity in appearance naturally suggests to the surgeon a similarity in the plan of treatment, and hence it has been recommended by high authority that the circumscribed traumatic aneurism should be treated by ligating the vessel before it reaches it, or, in other words, by cutting off its supply of blood, and trusting that a cure will take place in the same way as in spontaneous aneurism. But it sometimes happens that a cure fails to take place, for the following among other reasons: 1st, the occurrence of *gangrene* in the parts beyond the aneurism, and 2d, the *spontaneous opening of the aneurismal sac*, followed by *secondary hemorrhage* or *exhausting suppuration*. Now, it seems to me that the risk of the occurrence of a fatal result in either of these ways, may be considerably diminished by the performance of the old operation, instead of securing the vessel by a single ligature at a remote point. There is no doubt in my mind that by the old operation the danger arising from the spontaneous opening of the sac, with its subsequent hemorrhages and exhausting suppuration, would be greatly diminished, if not almost entirely removed; for the sac having been opened and cleared of its contents, would be converted into a simple wound, and would be likely to heal kindly from the bottom; and the distal portion of the artery being secured by a ligature, the blood could not escape backwards into the open sac; also, the proximal part of the artery being secured by a ligature

Objections to the plan of Hunter.

applied directly to it, the blood could not flow from it into the open sac, on the establishment of the collateral circulation with the vessels given off from the artery between the seat of deligation in its continuity and the aneurismal tumor.

Again, the risk of the occurrence of gangrene would be diminished in the following way: all the branches given off from the artery, before reaching the point of communication with the aneurismal sac, could be saved and utilized for the purpose of establishing and carrying on the collateral circulation; but this cannot be done if the artery is tied at a distance from the aneurism, as it is when the method of Hunter is employed.

Furthermore, the risk of consecutive gangrene is also much less when the old operation is performed for traumatic aneurism than when the method of Hunter or Anel is employed, because in operating on the old plan the aneurismal tumor becomes evacuated of its contents and subsides, the surrounding parts are thus entirely freed from its pressure, and the embarrassment to the blood-flow in the collateral vessels, occasioned by such pressure, is immediately relieved.

Indeed, it appears from the foregoing considerations, that if the formation of the aneurismal swelling itself does not give rise to consecutive gangrene, the old operation properly performed can but seldom lead to such a result.

Now, to counterbalance these important advantages in the treatment of circumscribed traumatic aneurism, which are obtained by laying the sac open, and tying the artery both proximally and distally at the seat of injury to it, there is but a single disadvantage. The operation is liable to be attended with the loss of considerable blood in all cases where a large artery is involved. This, however, in skillful hands, is not attended with danger, and, on that account, is a matter of but little consequence in the instances of the femoral, the brachial, and kindred arteries, because pressure can readily be applied in such manner as to control effectually the circulation of the blood in them. In the case of either of these arteries, dangerous or even profuse hemorrhage would be inexcusable. In such cases, most of the blood that is lost, if the operation be properly performed, belongs to the aneurismal sac or to the limb itself, having not been introduced into the limb subsequent to the commencement of the operation.

I think that Mr. Syme deserves much credit for having the sagacity to revive the old operation for aneurism, and the courage to practice it in those instances where very large arteries, for

example, the carotid, the axillary, and the common iliac, which are situated either in or near to the trunk, are involved. He fully deserves the remarkable success which he has achieved in these cases with the old operation.[1]

Mr. Syme revives the old operation.

CASE XXXVIII. *Immense Pouch-shaped Aneurism of the Femoral Artery, produced by Gunshot Injury, treated by tying the Vessel on both the Proximal and the Distal Side of the Orifice, with a Good Result. Compression of the Artery had been tried Forty-six Hours without Effect.* — July 16, 1863. The author was called by Dr. G. B. Hammond, Acting Assistant Surgeon, U. S. A., in charge of the Post Hospital at Camp Barry, to see a soldier named John Wilson, of the 27th N. Y. Battery, aged 26 years, of strong constitution, and a patient in that hospital on account of a large traumatic aneurism of the left thigh, with the following history: —

Old operation performed with excellent result.

He had been wounded by a pistol shot, May 26, 1863. The bullet entered the front of the left thigh at about its middle, and passing backwards close to the femoral vessels, lodged so deeply that it could not be extracted. The track of the bullet healed kindly. An abscess, however, formed in the back part of the thigh about three weeks afterwards, which was opened, explored with Nelaton's probe, and the presence of the bullet being detected by it, the opening was enlarged, a finger introduced, and then the bullet was readily removed. The abscess also healed kindly.

About a week after he was wounded, an aneurismal swelling, connected with the femoral artery, appeared directly in the track of the bullet. It increased in size but slowly, until about the 1st of July, "when its enlargement became quite rapid." On the 16th of June, two weeks after its commencement, Dr. Mursick reported it to be about as large as a hen's egg. On the 10th of July, compression of the artery on the cardiac side of the aneurism was resorted to as a means of cure, and was persisted in forty-six hours, when the patient had a convulsion, and the compression was discontinued, without, however, having produced any perceptible effect upon the tumor.

Four days afterwards, July 16th, when I first saw the case, the aneurism was very large, and occupied a great part of the antero-inner face of the left thigh. It was flattened in shape, and the pulsation and the aneurismal bruit were distinctly perceptible, upwards to within two inches of Poupart's ligament, and downwards to within four inches of the knee-joint. We decided to secure the femoral artery by ligature, in the neighborhood of the seat of injury. The aneurism appeared to be sacculated and developed exclusively from the inner side of the

[1] Vide *Medico-Chirurg. Transactions*, vol. xliii. p. 141; *Observations in Clinical Surgery*, by Syme, p. 154; and Holmes' *System of Surgery*, vol. iii. note opposite p. 1, and pp. 473, 488, 489, 518.

vessel. Dr. Hammond attempted to apply a ligature to the artery, on the proximal side of the aperture, without opening the sac, but failed, because the sac burst open from the necessary manipulations. The femoral artery had previously been compressed upon the pubis by the fingers of an assistant. The ruptured opening in the sac was then dilated by incisions, and the vessel tied from within the sac, on both the proximal and distal sides of the orifice, without difficulty, by Dr. Hammond.

I observed, when the sac was first opened, that it contained but little coagulum, notwithstanding that the artery had been compressed for forty-six hours only a few days before. After the proximal ligature had been applied, it was attempted to prevent hemorrhage from the distal side, until the distal ligature could be applied, by compressing the popliteal artery with a tourniquet and a large compress. But this failing, I readily controlled the distal bleeding[1] by pressing against the side of the artery with a finger applied near the orifice and from within the sac. While the proximal ligature was being applied, I readily restrained the hemorrhage by pressing firmly against the aperture in the vessel with a piece of sponge. The aperture embraced about one half the circumference of the artery. It was oval in shape; the long diameter corresponding with the course of the vessel. The interior of the sac was smooth in feel throughout its whole extent. The sac itself was very large in point of size, as it extended, when filled, from about two inches below Poupart's ligament, down to within four inches of the knee-joint. It was bounded in front by the *fascia lata*, and behind by the *adductor muscles*. It appeared to consist of condensed connective tissue. The blood, both fluid and coagulated, was carefully removed by wiping with a sponge, and the edges of the wound drawn together and retained in apposition by three points of interrupted suture and strips of adhesive plaster. The amount of blood lost during the operation was estimated at 32 oz., a large part of which belonged to the sac and not to the general circulation. The ligatures came away on the fourteenth day, July 30. The wound healed almost entirely by the first intention. The patient did well in every respect. There was not even coldness of the extremity after the operation. The femoral vein was not injured. The proximal ligature was applied at some distance from the orifice, which, however, was not measured. The patient began to do light duty seven weeks after the operation; and he became, three months after the operation, as well, apparently, as he ever was. The scar of the wound of operation was measured by Medical Cadet Gail, October 25th, and found to be six and a half inches in length.

Concerning distal hemorrhage in this case.

Description of the aneurismal sac.

Progress of the case after the operation very satisfactory.

[1] It should be stated here that the distal hemorrhage was profuse, *that the blood had a dark venous hue, and flowed in a steady stream*, both of which circumstances had been previously noticed by Guthrie in similar cases.

Comments. — This case illustrates well what I consider to be the proper surgical treatment of this form of traumatic aneurism; and an attentive consideration of the difficulties which presented themselves in the course of the operation, suggests to me the following method as one which may be followed with advantage in similar cases, namely: 1st, arrest the influx of blood by compressing the artery completely and reliably, either by the fingers of an assistant, or by a tourniquet, on the cardiac side of the aneurism; 2d, lay open the sac freely enough to afford room, at the outset, to work without embarrassment; 3d, next find the aperture in the artery, by carrying the finger along the part of the sac in immediate relation with the artery, and by careful exploration in this locality it will seldom fail to be quickly discovered; 4th, now place the finger of an assistant so as to compress the vessel laterally from within the sac, both above and below the orifice in it, and the blood belonging in the limb will immediately cease to flow out into the sac — the more freely the sac has been opened, the more readily of course can this important step be accomplished; 5th, now remove the coagula, and sponge out the sac cleanly; this exposes the aperture in the artery to view; then open the sheath of the artery close to the hole in it on the proximal side thereof, and pass a ligature round it with Mott's aneurism needle. As soon as this ligature has been tied, the assistant's fingers, compressing the proximal part of the vessel from within the sac, should be withdrawn. This will give more room for applying a ligature on the distal side of the orifice, which should now be done.[1] Open the sheath of the artery carefully, near the orifice on its distal side, and pass the ligature again with Mott's needle. Tie the ligature, withdraw the assistant's fingers from compressing the distal part of the artery, and the operation is completed.

How to avoid difficulties of the old operation.

The facility of performing this operation depends mainly upon opening the sac at the commencement by a sufficiently free incision, and upon discovering promptly the precise locality of the opening of communication between the artery and the sac, and upon the assistant's fingers compressing the vessel carefully from within the sac, on both the proximal and the distal sides of the orifice, thus preventing the flow of any blood into the sac, which, if permitted, would obscure the parts, and of necessity delay the application of the ligatures.

[1] Deschamps has recommended that the distal ligature be applied first, *i. e.* before the proximal, and in some cases it will be found advantageous to do so, for in that way the annoyance occasioned by distal hemorrhage will be entirely avoided.

This operation should not be undertaken without the aid of competent assistants, if such are within reach; for in no other operation is such aid more important when a large artery is involved. I have taken the liberty of stating the method of performing it at considerable length, because the steps of the operation, which may become important and difficult of execution in the case of any large vessel, have not been laid down by writers on operative surgery. I am also confident that this discussion will prove useful to the surgeon who is about to undertake the performance of this operation, and at the same time tend somewhat, I hope, to dispel the dread of hemorrhage, which seems to appertain to the performance of this operation, especially for traumatic aneurism connected with a large artery.

By the time that the distal ligature has been tightened, it will be seen that the sac has become much contracted. Now sponge out carefully any blood, whether fluid or coagulated, that there may be in it; draw the free ends of the ligatures out; approximate the edges of the wound, and secure them with a few points of interrupted suture and strips of adhesive plaster. A roller bandage should not, under ordinary circumstances, be employed as a part of the dressing, because by constricting the limb it would tend to embarrass the establishment of the collateral circulation. If it were not applied tightly enough to do that, it would be useless as a dressing, and on that account should not be kept on the wound. The temperature of the limb should be maintained by the application of artificial warmth, if necessary, as was done in the case of Captain Jordan. Care should be taken that the bottles of water, or the bricks employed for the purpose, are not so hot as to burn the limb.

But in case of traumatic aneurism of the *axillary* artery, the surgical treatment becomes more difficult, because, in the first place, of the proximity to the centre of the circulation; and, in the second place, because external pressure cannot be applied in a way to shut off the flow of blood to the aneurism, with certainty, as readily as in many other parts of the body; for the subclavian artery as it passes over the first rib lies deep down behind the clavicle. In Jordan's case, I tied the artery as near as possible to the aneurism on the side next to the heart, because it is the operation which is sanctioned by authority, and because it was recommended by a consultation of my colleagues, all of whom were military surgeons of experience. It was my opinion then, which was also fully expressed at the consultation, that the best procedure

would be to compress the subclavian artery on the first rib as carefully as possible, then to open the sac freely by incision, and to secure the bleeding end of the severed artery with a ligature; but I was not yet impressed strongly enough with the correctness of this view to put it into practice against the advice of my colleagues intrenched behind the teachings of authority. However, after following the case attentively to its fatal close, by secondary hemorrhage and exhausting suppuration, and after making the autopsy, I have no doubt that his chance of recovery would have been, to say the least, considerably better if that operation had been performed. The principal advantages of the operation proposed in the case of Jordan over the operation performed, are, in the first place, that it overcomes the danger arising from exhausting suppuration of the sac for the most part; for by it the sac is converted into a simple wound, with a strong tendency to heal from the bottom; and, in the second place, it does away almost entirely with the risk of relapse and of secondary hemorrhage, for it leaves no vessels with unclosed mouths in the sac, ready to bleed as soon as the collateral circulation is sufficiently established.

The disadvantage of the proposed operation is the risk arising from the hemorrhage (primary) attending the operation itself: but I am now inclined to believe that by compressing the subclavian artery against the first rib, according to the method recommended by Guthrie, this risk is more apparent than real, even on the supposition that very great difficulty be experienced in discovering the ends of the severed artery. It seems to me that a fair statement of the matter would be this: the operation performed afforded the patient a *reasonable chance* of recovery, while the operation proposed would have made recovery *nearly certain*. Guthrie proposed to compress the subclavian artery with the thumb-piece of the screw of an ordinary tourniquet, wrapped up in a piece of bandage so as not to injure the skin, and pressed firmly downwards and backwards behind the clavicle. The inverted tourniquet would afford an excellent hold for the hands of the assistant, if compression were required to be continued for a long time. In this way any *competent assistant* would be able to effectually control the circulation of blood in the subclavian artery, in ordinary cases. We should, however, state, before leaving this part of the subject, that there is no doubt but that *the treatment of traumatic aneurism should be modified according to the peculiarities of each case*, especially with respect to the situation of the aneurism, and the character of the parts overlying and surrounding it.

Treatment should be adapted to peculiarities of case.

For example, we would not treat an aneurism of the ulnar arch in the palm of the hand by opening the sac and tying the artery from within it, until other means, such as compression, etc., had been tried without success, because the operation would require the division of the annular ligament, and consequently would produce permanent impairment of the functions of the hand. The duration of a traumatic aneurism may also call for modification in the surgical treatment. The slower its development and the longer it lasts, the more closely it resembles a spontaneous aneurism, and the more amenable it becomes to the treatment successful in spontaneous cases. It appears, further, that the more chronic a traumatic aneurism is in respect to growth, the more likely it is to undergo a spontaneous cure by the filling up of the sac with laminated fibrin, or with coagulated blood.

The following case has been introduced here, because it is the first example which I have found on record, of traumatic aneurism produced by gunshot injury. It is also the first instance on record in which the old operation for aneurism was employed for the relief of the consequences of wounds inflicted by gunshot projectiles; wherefore, the case possesses unusual interest for him who cultivates the science and art of surgery, in the enlarged sense of the term. It occurred in the practice of M. A. Severinus, and was placed on record by that writer in 1646.

Case XXXIX. *Gunshot Wound of Right Thigh involving Femoral Artery; Traumatic Aneurism; Secondary Hemorrhage occurred several Times; cured finally by opening the Sac and tying the Artery both above and below the Place of Injury.* — Jacob, aged 17, the son of the officer commanding the halberdiers of Campania, was wounded in 1646, in the right thigh, about eight fingers' breadth below the groin, by a musket ball, which entered between the rectus, gracilis, and vastus externus muscles, and escaped on the opposite side through the triceps, wounding the femoral artery in its course. A very copious flow of arterial blood immediately occurred, which appears to have been arrested by compression.

The next day the bandages were loosened. It was then found that the part had swollen very considerably, and was pulsating in such a way that both hands, when laid upon the tumor, were lifted up by the pulsations. The swelling was treated by bandaging and by the application of astringents and refrigerants. Occasional bleeding to the extent of three or four ounces, but ceasing spontaneously, took place from it for several days. The blood burst forth again on the seventeenth day, and Severinus was called in to see the case. He found that the wound was

free from all unhealthy action, and that the swelling and pulsation had diminished. Believing that the plan of treatment agreed with the patient, the surgeons decided that it should be continued, with the addition of a liberal allowance of wine for the purpose of keeping up his strength. The hemorrhage continued to be restrained for thirteen days, when it burst forth again, and then ceased spontaneously.

Afterwards the patient's strength continued to diminish. Severinus says; "and as his face as well as the other parts of his body grew thinner daily, we had a sad affair to deal with; nor did there appear to be a chance of recovery in any other way (if indeed there were any) than by dilating the wound, so that the artery might either be stitched up, or ligatured, or burnt with caustic, or the flow of blood be arrested in some other way." As a remedy of last resort, the patient was operated on in the following way, in the words of Severinus: "We first sought for the artery near the groin, and following it a little below this, a hard compress was applied over its course, and the thigh was bound up with a tight ligature in the same way as when some part of it is to be amputated; so that the vessel being rendered narrower by the pressure might pour out a smaller quantity of blood during the operation. This having been done, we marked the part of the skin that was to be cut with ink, and Johannes[1] having made an incision along the part that was marked, a large quantity of grumous blood, weighing at least six pounds, immediately appeared; this mass of blood being quickly removed, the artery was sought for, on finding which the hemorrhage was arrested by powerful pressure with the fingers, Johannes Trullius pressing strongly on the groin; we had now the artery plainly in view, which I separated from the accompanying vein and tied, first in the upper, then in the lower part, the same precautions having been taken that are attended to in varices. The artery was torn to about a third of its diameter, a portion being left, which, on the day after the application of the ligature, was divided by Johannes Trullius, lest perchance it should draw the ends together before they sloughed. The further progress of the case was like that of a simple wound, and it was completely terminated in six weeks; Ferranti, Serroni, and many others being in attendance."[2]

The foregoing account has been much abridged from the narrative of the case which was made by Severinus. The result in this case was all the more gratifying, because the patient made a speedy recovery.

Although we have strongly advocated the employment of the old operation for the relief of traumatic aneurism of the femoral, as well as of the axillary and brachial arteries, especially the two former, we know that a cure may sometimes be obtained by the

[1] Johannes Trullius, a celebrated lithotomist and surgeon.

[2] Vide *Observations on Aneurism*, translated and edited by John E. Erichsen, p. 191 *et seq.*, Sydenham Soc. ed., London, 1844.

employment of the operation of John Hunter, or that that of Dominique Anel in such cases. We prefer the old operation for traumatic aneurism, because we believe that it is more likely to prove successful in the treatment of that affection, than the operative procedures devised by Anel and Hunter. We know that a considerable proportion of the cases of traumatic aneurism after being operated on by the methods of Anel and Hunter, recover; but we are also convinced, that a still larger proportion of the same class of cases, when operated on by the method of Antyllus, terminate successfully. We consider the old operation to be the best one for most cases of traumatic aneurism, because it is not liable to be followed by relapse, and because it has proved to be the most successful one.

Why we generally prefer the old operation to that of Anel or Hunter

The next case, however, affords an example of traumatic aneurism of the femoral artery which was cured by the Hunterian operation. It is related here for the purpose of enabling us to obtain views as broad as possible concerning the surgical treatment which should be employed for the cure of traumatic aneurism, and views as complete as possible of the surgery of the late war.

CASE XL. *Gunshot Wound involving Femoral Artery; Profuse Arterial Hemorrhage (Primary) which was arrested by Pressure; Traumatic Aneurism subsequently produced; Ligation of the Femoral Artery on the Hunterian Principle; Recovery:* reported by Philip S. Wales, M. D., Surgeon U. S. N. — James O'Neal, aged 30, was sent to hospital March 28, 1863, with a gunshot wound of left thigh, at lower third, involving the track of the femoral artery. Ten days had elapsed before he reached the hospital. There was profuse arterial hemorrhage at first, which was arrested by the tourniquet. Subsequently an enormous diffused traumatic aneurism was developed. On admission to the hospital the tumor occupied the lower two thirds of the thigh, and its pulsation could be felt throughout this portion of the limb, except a narrow strip on its outer side. The aneurismal bruit was distinctly felt and heard immediately after the impulse was communicated to the touch.

April 2. — Ligated the femoral artery in its upper third. The pulsation of the tumor was immediately arrested. Chloroform was employed as an anæsthetic. He bore the operation well. Morphia was administered to induce sleep.

April 3. — Patient comfortable; temperature of limb good; femoral artery at groin pulsates slightly — 69 per minute.

April 6. — Patient doing well; all pulsation has disappeared from the limb.

April 8. — A distinct pulsation can be felt in the posterial tibial artery to-day.

April 11. — Has continued to improve; the upper part of the incision has healed from the bottom almost to the surface, with slight discharge of pus, and the limb has nearly regained its normal size.

April 19. — Wound of operation almost healed; the place where the aneurism was situated imparts the sensation of great solidity.

May 1. — The ligature came away to-day; patient's condition excellent.

May 30. — He was discharged from the hospital cured, and sent to the guard-ship for safe keeping, until he should be disposed of by the naval authorities, as he was a blockade-runner.[1]

While the success which attended the treatment of this case was the source of much satisfaction, it does not by any means show the Hunterian operation to be preferable to that of Antyllus for traumatic aneurism of the femoral artery. The objection to the Hunterian operation in such cases is that it not unfrequently fails, through the occurrence of consecutive gangrene, or of secondary hemorrhage, or through the return of pulsation in the tumor with other signs of relapse, when the old operation would probably have succeeded.

When traumatic aneurism of the thigh is treated on the plan of Hunter or Anel, consecutive gangrene seems more likely to occur than when the old operation is performed, for reasons that have already been stated at sufficient length;[2] and the more recent the origin of the aneurism the greater the risk becomes that such a result will be produced. In the following case, which occurred in the practice of Prof. F. H. Hamilton, to whom I am indebted for the notes of it, a traumatic aneurism of the thigh, diffuse in character, was treated by ligating the femoral artery on substantially the plan of Anel. The operation was speedily followed by dry gangrene of the foot and leg; but a line of separation fortunately appeared, the thigh was amputated, and in the end the patient was saved, *minus* his limb.

Case XLI. *Gunshot Wound of Thigh; Femoral Artery injured; Traumatic Aneurism; Anel's Operation performed Twenty-nine Days after Injury; Consecutive Gangrene speedily produced; Amputation of Thigh; Recovery.* — Henry Tainter was wounded in the thigh by a pistol-ball, December 31, 1853, at Buffalo, N. Y. The femoral artery was injured just below the origin of the profunda, and a large traumatic aneurism, of the diffuse variety, was formed in consequence of that

[1] Vide *American Journal of Med. Science*, April 1864, pp. 551, 552, from which the foregoing account of the case has been condensed.

[2] See pp. 117, 118 of this essay.

lesion. On the 29th of January, 1854, Prof. Hamilton operated on this patient. The aneurismal swelling then extended from the origin of the profunda down to the middle of the thigh. He tied the femoral artery between Poupart's ligament and the profunda, with two ligatures, placed about half an inch apart, the patient being under the influence of chloroform. The limb became cold, and bags of hot sand were applied to it in order to restore and preserve its temperature. In a few hours pain commenced in the leg.

January 30. — This morning there was no sensibility below the knee. A white spot, like a cicatrix, appeared on the leg, about its middle, in front of the spine of the tibia. The remainder of the leg soon became mottled, the toes became white, and great pain in the knee appeared. Some vesication of the leg was produced by the hot applications. Morphia and wine were prescribed. In the course of a few days the white spot changed to a black color and began to slough.

February 18. — The ligatures came away.

February 28. — A line of demarcation formed just below the knee.

March 1. — Three epileptiform convulsions occurred. He had never had fits before.

March 17. — Amputated the thigh six inches above the knee, the patient being under chloroform. The administration of chloroform was followed by temporary delirium, both on this and the previous occasion. The patient ultimately recovered.

The plan of Hunter is, sometimes preferable in the leg and ham.

There is, however, one region of the body wherein, after some experience and much reflection, I am inclined to believe that the operative procedure devised by Hunter is sometimes preferable to the old operation for the cure of traumatic aneurism, and that region is the leg, including the popliteal space. But in all other parts of the body the operation of Antyllus is, in general, to be preferred.

Dupuytren the first to conceive and execute this proposal.

The great master in practical surgery of France in recent times, Dupuytren, was the first to proclaim and at the same time strongly present his belief to the profession, that cases of traumatic aneurism of the leg, produced by simple fracture of its bones, and even by gunshot lesions, are more likely to have a good result when treated by tying the femoral artery, than when they are treated by cutting down upon the wounded vessel and securing its bleeding ends with ligatures applied at the place of injury, as originally practiced by J. L. Petit, on the one hand, or by amputating the leg on the other. Before the time of Dupuytren traumatic aneurism of the leg, occurring in connection with fracture of its bones, and gunshot wounds, was treated either by the old operation, or by amputation of the mem-

ber; but the latter procedure was generally recommended. In the year 1809 an old woman was brought to the Hotel-Dieu, who had simple fracture of the leg, complicated with diffuse aneurism. The consideration of her case, aided by previous observation of similar instances, induced Dupuytren to perform the Hunterian operation for her relief. His success was complete.

The following is the narrative of the case, together with a statement of the reasons which led him to operate on the plan of Hunter, in his own words, except the heading, which is my own.

Case XLII. *Simple Fracture of the Leg, accompanied by a Wound of the Posterior Tibial Artery, inflicted by the Broken Bone; Traumatic Aneurism successfully treated by ligating the Femoral Artery according to the Method of Hunter.* — Marthe Marie Barbe, a female, aged 62, of spare habit, but enjoying pretty good health, slipped and fell whilst running in the street, in January, 1809. She felt pain, and was conscious of a snap at the lower part of her leg, at the time of the accident. On the following day she was brought to the Hotel-Dieu, and I at once detected that both bones of the leg were broken at the junction of the middle and inferior thirds. The fracture was oblique, and accompanied by displacement of the fragments forwards and backwards; there was likewise great swelling and tension of the surrounding soft parts. On attempting the reduction, I felt at the back part of the leg, in the calf, diffused but strong pulsation, distinct to the eye as well as to the touch, and synchronous with the heart's action: this was controlled when pressure was made on the femoral artery, but returned as soon as it was removed. There could, therefore, exist no doubt as to the real and serious nature of the case, which was evidently one presenting the complication of an artery wounded by the fractured extremity of one of the bones, either at the time of the accident, or subsequently in moving the patient; and I inferred from the position of the extravasation, that the posterior tibial was the vessel lacerated; and that the lower fragment of the tibia, which projected backwards, had produced the mischief. As the circumstances of the case did not call for immediate interference, and its nature was such as to demand reflection, I determined to defer taking any step until the evening.

What was I to do? The age of the patient was against her; but was she to be abandoned to her fate, without an attempt to save her?

Should I adopt the practice of J. L. Petit, and cut down upon the wounded artery and tie its bleeding extremities? The difficulties of such a search at the bottom of a deep incision through the muscles, and in the midst of soft parts confounded together by a mass of extravasated blood, restrained me from acting on this suggestion. Supposing even that I had succeeded in securing the bleeding vessel, the operation itself would expose

Dupuytren's remarks on this case. They are very interesting and instructive.

the patient to all the perils attending the exposure of a large cavity filled with blood, in direct communication with the fractured extremities of the bones; to say nothing of the consequent difficulties and hazard associated with the dressing of such a wound.

One other alternative presented itself, namely, that of amputation through the thigh. This certainly had the merit of being a simple and expeditious mode of extrication from the difficulty. But, apart from the distressing mutilation which such a proceeding would entail upon the patient, even if she recovered, I could not but be mindful of the fatal result which had attended a similar step in several cases analogous to the present.

The preferable course seemed to be the application of a ligature on the main artery of the limb at a distance from the seat of mischief. This would arrest further bleeding from the lacerated artery, and allow time for it to close. It would further supersede the necessity for laying open the large sac containing the extravasated blood in the neighborhood of the fracture, and exposing it to the risk of inflammation and dangerous suppuration. This, then, seemed to me to be a reasonable step; but I had neither precedent nor experience to guide me with regard to its safety. I feared that the obstruction to the circulation might induce gangrene; or, on the other hand, that the too speedy restoration of the blood to its natural course through collateral channels, might render the attempt useless; or, again, that the irritation set up by the fragments of the broken bones, and the presence of the effused blood, might be succeeded by inflammation and suppuration. I resolved, however, to make the attempt of tying the femoral artery in the middle of the thigh; and this operation was accordingly performed with unusual facility. A triple ligature was carried round the vessel, and tightened, with the effect of immediately arresting all further pulsation in the tumor.

I was gratified to find that neither the temperature nor the sensibility of the limb were in the least interfered with. On the fifth day, the anastomotic branches around the knee could be both seen and felt. On the sixth day, the tumor was reduced one third in bulk, and continued to diminish, progressively, until it ultimately quite disappeared. The ligature on the artery came away on the fifteenth day, and the wound made for its application was healed in six weeks.

Some spots which made their appearance on the leg led me to fear at one time that gangrene was impending; but this proved to be a false alarm. A slough, produced by the pressure, separated from the heel, and the wound which it left healed kindly.

In the meanwhile, the union of the fracture proceeded but slowly. The formation of the callus was scarcely commenced at the end of the first month, and it was not perfectly consolidated before the expiration of four months. The woman perfectly recovered the use of her limb; and I

have had the opportunity of seeing her from time to time for fifteen years afterwards in the enjoyment of perfect health.[1]

In 1815, M. Delpech, of Montpellier, met with a case similar to, and even more complicated than the preceding, which he treated in the same way, and with corresponding success. M. Delpech's patient was injured by being run over by a loaded cart, whilst in a state of drunkenness; both bones of the leg sustained a comminuted fracture, near the centre; an artery was lacerated, and a diffused traumatic aneurism was produced. The femoral artery was tied towards the upper part of the thigh. Delpech's case.

On the tenth day, the wound in the thigh was almost entirely healed. On the twenty-fifth day, it opened again, to allow the exit of the ligature; the union of the fractured bones was going on satisfactorily. At the end of three months the patient walked without crutches; and, though there was some difference in the volume of the two limbs, there was not the least deformity.[2]

In 1818, Dupuytren also treated a case of traumatic aneurism of the leg, the result of a *gunshot wound*, by the same method, and with entire success.[3] Dupuytren's case.

From a perusal of Dupuytren's cases, it appears that he objected to treating traumatic aneurism of the leg, connected with simple fracture of its bones, by amputation of that member, in the first place, because of the distressing nature of the mutilation, and in the second place, because of the great mortality which attends that operation. Dupuytren's objections to amputation.

He declined to treat such aneurisms of the leg by the old operation, because of its seeming impracticability, it being impossible to decide what vessel required a ligature, whether to cut down through the front or the back of a limb, or whether the bleeding might not proceed from more than one artery. Moreover, he says, these operations on the arteries of the leg are not easy, even under favorable circumstances; and in cases where the surrounding parts are broken down and disorganized, such a proceeding may be fairly deemed impracticable. But it is probable that he overestimates somewhat the difficulties which attend this operation. His objections to old operation.

It should, however, be remembered that much injury is apt to accrue to the patient from attempting the performance of an impracticable operation. For, under such circumstances, he is likely to be kept a long time upon the operating table, under the influence

[1] Vide Dupuytren on *Lesions of the Vascular System*, Sydenham Soc. ed. pp. 8, 9, 10.
[2] *Op. cit.*, pp. 10, 11. [3] *Op. cit.*, pp. 12, 13, 14.

of chloroform or some other anæsthetic, the combined result of which is that the patient sustains a large amount of shock, and has his chances of recovery sensibly diminished thereby.

When the fracture is compound.

The writer feels confident that in cases of traumatic aneurism of the leg produced by simple fracture of its bones, more limbs can be saved by tying the femoral artery than by the performance of the old operation. But when the fracture is compound or gunshot in its nature, it is generally preferable to employ the old operation when practicable, or else to amputate the leg without delay when the injury is so extensive that gangrene is likely to ensue.

Mr. Holmes' remarks.

Concerning traumatic aneurism complicating fracture, Mr. Holmes says: "Four cases have occurred at the Middlesex Hospital, under the care of Mr. Moore and Mr. Mitchell Henry, in which such traumatic aneurisms have formed, and have got well spontaneously."[1] The history of these cases, as related, does not appear to justify so strong a statement. There is reason to doubt whether the main artery of the broken limb was laid open in either of them. It seems probable that some vessel of minor importance was injured, and that the hemorrhage from it ceased on placing the limb at rest in a suitable position.

Resumé of surgical treatment of traumatic aneurism.

Traumatic aneurism of the *popliteal artery*, when produced by a gunshot wound and of recent origin, should generally be treated by amputation, as was done in the case of Schatt (Case X.).

But when traumatic popliteal aneurism becomes chronic, when the collateral circulation is no longer embarrassed by inflammatory swelling of the parts about the knee, and when the tumor is small, the Hunterian operation should generally be preferred.

Generally, the *old operation* should not be performed in the popliteal space, because it is apt to be followed by gangrene of the foot and leg, or by protracted and dangerous suppuration,[2] owing to peculiarities in the anatomical structure of the part.

Traumatic aneurism of the *femoral artery* should generally be treated on the old plan.[3]

When traumatic aneurism occurs in the *common iliac artery or its branches* it is generally advisable to employ the old operation.[4]

[1] See Holmes' *System of Surgery*, vol. iii., p. 443.

[2] See case of Repasses, No. XXXIV.

[3] See cases of John Wilson and Jacob, Nos. XXXVIII., XXXIX.

[4] See Mr. Syme's case, referred to in Holmes' *System of Surgery*, vol. iii., note opposite p. 1; also *Medico-Chirurg. Transactions*, vol. xlv.

The abdominal aorta should be compressed against the vertebral column by Mr. Lister's horseshoe clamp, and thus the operation can be performed with safety and without the effusion of much blood.

Traumatic aneurism of the *common carotid artery or its branches* should be treated by the old operation whenever it is practicable to perform it.[1] If for any cause the old operation cannot be performed in such cases, there seems to be but little hope of making a cure.

When traumatic aneurism occurs in the *axillary artery* the old operation should generally be performed.[2]

Traumatic aneurism of the *brachial, radial, and ulnar arteries*, should, for the most part, be treated on the old plan; but the cure of aneurism of the palmar arch should generally be attempted by tying the brachial artery on the plan of Hunter, because the performance of the old operation would seriously impair the usefulness of the hand from division of the annular ligament. Experience has shown that the ligation of the brachial artery is more likely to cure traumatic aneurism of the palmar arch, than the ligation of the radial and ulnar arteries. The first-named operation is usually successful in such cases. The risk of consecutive gangrene being produced by operations on the arteries of the arm and fore-arm is very small, because the collateral circulation is very readily established when either of them happens to be occluded, unless the parts are greatly tumefied by inflammatory swelling.

The next two cases afford examples of the distressing and even deplorable circumstances under which the surgeon is sometimes called upon to operate in cases of traumatic aneurism. In the first case the result was satisfactory. In the last case recovery might have taken place, if the old operation for aneurism had been seasonably performed. The same case also forcibly illustrates the inutility of local compression as a curative measure in cases of traumatic aneurism of the axillary artery, or any other vessel having a considerable size.

Case XLIII. *Ligature of the Subclavian Artery for Traumatic Aneurism of an Arm-stump; Recovery.* — Prof. Armsby, of Albany, performed this operation on a healthy, robust man, 28 years of age, who had his right arm shattered by the accidental discharge of a cannon, July 7th, 1863.

Gangrene commenced on the second day, and on the third Prof. A.

[1] See Mr. Syme's case, *Observations in Clinical Surgery*, p. 154; also Holmes' *System of Surgery*, vol. iii. pp. 488, 489.

[2] See Mr. Syme's case, *Medico-Chirurg. Transactions*, vol. xliii.; also Holmes' *System of Surgery*, vol. iii. p. 473; see also the case of Captain Jordan, No. XXXVII. of this essay, and the comments thereon, including Sir Charles Bell's case, mentioned on p. 114.

amputated near the shoulder. The stump healed kindly, and on the twelfth day after the operation he was able to go out, and soon after resumed his active business pursuits.

His health remained good until September, when the stump began to swell and be painful, and on the 10th of November Prof. A. detected an aneurismal tumor. This tumor increased rapidly, elevating the bones of the shoulder, the pectoral muscles, and filling the axilla. The skin soon after gave way, and the patient lost by sudden and rapid hemorrhage between two and three quarts of blood, causing faintness and almost loss of pulse. The opening was closed by compresses and adhesive plaster. The only chance of saving life seemed to be afforded by ligation of the subclavian artery above the clavicle. That operation was performed by Prof. A., November 19th. The pulsation in the tumor ceased as soon as the ligature was tied. The patient improved rapidly under the use of tonics. The sac gradually diminished until the nineteenth day after the operation, when it became more painful, and the skin, or a portion of it, gave indications of sloughing. Prof. Armsby then opened the sac, and removed nearly a quart of coagulated blood and fibrinous matter.

The ligature came away on the twenty-ninth day, and the patient made a good recovery.[1]

Case XLIV. *Traumatic Aneurism of Axillary Artery following Gunshot Wound; treated unsuccessfully with Local Compression; Rupture of the Aneurismal Sac and very Profuse Hemorrhage, which ceased spontaneously; Deligation of the Subclavian Artery external to the Scalenus; a Large Nerve was included in the Ligature; Death Six Hours after the Operation;* reported by Isaac Norris, Jr., M. D., Acting Assistant Surgeon U. S. Army. — H. Grothern, sergeant Co. K, 5th U. S. Cavalry, was admitted into the McClellan U. S. Army General Hospital, June 23d, 1863, with an aneurism of the right axillary artery, the result of a gunshot wound inflicted at Beverly's Ford, June 9th.

When Dr. Norris took charge of the ward to which this patient belonged on the 26th of July, he was absent. He returned on the 28th, and after making a careful examination of the case, a traumatic aneurism, about the size of a large horse-chestnut, was found connected with the axillary artery.

Dr. Norris's predecessor had had an apparatus made by which graduated pressure could readily be applied to the affected part. This apparatus was adjusted, but, after a trial of some thirty hours, it was abandoned on account of the pain it gave the patient, and a padded bandage was substituted, in the faint hope that it might be of use. This bandage was worn about ten days, when it was discontinued, and the treatment was reduced to keeping the arm, as nearly as possible, at perfect rest.

[1] Vide *American Journal Med. Sciences*, April, 1864, pp. 564, 565.

August 16. — The aneurism became much larger, and from pressure upon the axillary plexus of nerves occasioned much pain. The aneurismal sac broke early on the morning of the 17th, and between thirty and forty ounces of blood were lost. The hemorrhage ceased spontaneously, but it had brought him so low that it was thought advisable not to perform any operation at that time. Digital compression was employed with a view to prolong the patient's life.

Surgeon R. H. Coolidge, Medical Inspector, saw the patient, and thought the subclavian artery should be tied in the third part of its course. After the lapse of several hours the hemorrhage returned, and that operation was then (6 o'clock, P. M.) performed by Medical Inspector Coolidge.

The patient seemed to do well until about 8 o'clock, when he complained of considerable pain in the wound. Morphia was freely administered, but without relief. He grew rapidly worse, exhibited great dyspnœa, and died at midnight, six hours after the operation.

The *autopsy* revealed the unexpected fact that a nerve, of considerable size, lying immediately behind the artery, was embraced in the ligature.

At the time the vessel was tied the patient appeared to be but slightly under the influence of the anæsthetic (chloroform). No pain was manifested until about two hours afterwards.

The great loss of blood which occurred in the morning exerted a very important influence in producing the fatal result.[1] This account of the case has been considerably abridged from that contained in Hay's Journal.

Comments. — Compression has been applied in two situations for the relief of traumatic aneurism: 1st, over the aneurismal swelling itself; 2d, on the trunk of the wounded vessel, before it reaches the tumor.

In the case just related, pressure was specially employed in the first of these situations for the purpose of arresting the growth and effecting a cure of the aneurism. How signally it failed let the melancholy result answer. Local compression of the aneurismal tumor did no good whatever as a curative measure in this instance, nor in the case of Tapka (No. I.), nor in case No. VII., nor in that of Schatt (No. X.), nor in that of Repasses (No. XXXIV.), nor in that of Finley (No. XXXV.), nor in that of Jacob (No. XXXIX.), nor in any other case that we have related where it was employed. In all of these cases it proved useless as a means of cure; in some of them it was positively detrimental. The surgeon might be lulled

Compression as a curative measure for traumatic aneurism in general.

[1] Vide *American Journal Med. Sciences*, January, 1864, p. 128.

into a false security by the employment of this measure, and thus might be induced to delay the performance of any operation that would prove useful, until hemorrhage of a fatal character supervened, as seems to have happened in the case just related.

Not adapted to acute traumatic aneurism.

With regard to pressure applied to the trunk of the wounded vessel on the cardiac side of the tumor, it was employed in only one instance, that of Wilson (No. XXXVIII.). In that case it did no good, although it was kept up for forty-six hours, and until convulsions occurred. Indeed, compression seems entirely inadequate for the treatment of acute traumatic aneurism where a large vessel is concerned, and precious time should not be wasted in its use, nor in the employment of any other inefficient means of cure.

CHAPTER FIFTH.

ON WOUNDS OF THE VEINS.

Gunshot Wounds of Veins of a Serious Nature occurred but very rarely during the Late War. — An Instance mentioned. — Another Instance referred to. — Two Cases in which Large Veins were wounded by Gunshot Projectiles will also be related. — In One of them, which was contributed by Dr. Swarts, the Ball fractured the Lower Jaw and passed downwards into the Neck, fracturing also the Transverse Processes of the Third and Fourth Cervical Vertebræ; it wounded the Internal Jugular Vein and lodged; Secondary Hemorrhage repeatedly occurred; the Patient ultimately died in Convulsions; Autopsy. — Our Army Medical Museum contains Two Specimens belonging to the same Category. — An Illustrative Case contributed by Dr. Leale. — Gunshot Wound of Femoral Vein; Death Seventeen Days afterwards from Exhaustion, produced by Hemorrhage, which frequently recurred. — Our Army Medical Museum also contains Two Specimens which were obtained from Cases similar to the One just related. — Remarks by the Surgical Historian of the British Army in the Crimean War on the Traumatic Lesions of Veins. — A Case briefly quoted from his Work. — Also his Remarks on Venous Hemorrhage and Consecutive Gangrene occurring when the Main Artery and Vein are both wounded. — Our Army Medical Museum contains Three Specimens, in which Large Arteries and their Accompanying Veins were wounded by Gunshot Projectiles. — Our Army Medical Museum also contains a Specimen of *Punctured Wound* of a Vein. The Femoral Vein was pierced by a Darning-needle. — Wounds of Veins an Important Subject for Three Reasons, which are enumerated. — Certain Forms of Venous Compression promote Venous Hemorrhage; they are enumerated. — On the Influence of Posture in promoting Venous Hemorrhage. — Treatment of Hemorrhage from Wounded Veins. — We should endeavor to restrain the Bleeding from Wounded Veins: 1st, by obviating the Conditions which promote it; 2d, by the Employment of Compression; 3d, by the Application of Ligatures. — The Author's Experience in tying Veins. — Dr. S. W. Gross' Valuable Paper on the same Subject. — Gunshot Wounds of the Femoral or the Popliteal Vein, with Corresponding Lesion of the Accompanying Artery, generally require Immediate Amputation. — The Reasons stated. — Dr. W. Thomson's very Interesting and Instructive Case, which belongs to this Category, is referred to at some Length.

GUNSHOT wounds of veins of such a character as to prove troublesome in their management, must have occurred very rarely indeed during the recent War of the Rebellion, for we are informed, as already mentioned, in Circular No. 6, that "no cases have been reported in which the bleeding could not be controlled by pressure."[1]

The author, however, remembers to have heard it stated by a distinguished surgeon, while describing a wound of the brachial artery, that one of its venæ comites also was wounded, and required the application of a ligature to suppress the bleeding from it, after pressure had been tried in vain. Ligature to venæ comites.

In the case of profuse venous hemorrhage which I saw at the

[1] Page 39.

battle of Ball's Bluff, and to which reference has already been made in the chapter on primary hemorrhage from gunshot wounds, pressure alone sufficed to stop the bleeding.[1]

Internal jugular and femoral.

We have also received the reports of two cases wherein gunshot projectiles wounded large veins, in one case, the internal jugular, and in the other, the femoral vein, both of which proved fatal. They possess considerable interest, especially on account of their comparatively infrequent occurrence, and, for that reason, they are here related. The following case was contributed by Dr. D. J. Swarts, Assistant Surgeon 100th Indiana Volunteers : —

CASE XLV. *Gunshot Fracture of Lower Jaw ; the Ball passed downwards into the Neck, fracturing also the Transverse Processes of the Third and Fourth Cervical Vertebræ ; it wounded the Internal Jugular Vein and lodged ; Secondary Hemorrhage repeatedly occurred ; the Patient ultimately died in Convulsions ; Autopsy.* — M. A. Rupert, private Company E, 46th Ohio Volunteers, wounded at Dallas, Ga., May 27th or 28th, 1864 ; admitted into hospital May 28th. A ball entered the face about the middle of the buccinator muscle, on the right side, fractured the inferior maxilla, of that side, passed downwards into the neck, on the same side, and lodging, could not be felt.

May 30. — He felt well ; had a good pulse and a good appetite, but could swallow liquid food only. He continued to do well until the night of June 7th, when *some hemorrhage* from the wound occurred. On the night of June 8th, *profuse hemorrhage* from the wound took place. His pulse became feeble and his appetite poor.

June 9. — He appeared much better ; pulse full ; appetite good ; from this time he improved.

June 14. — He was able to walk about. (There was a purulent discharge from the wound from June 3d to the time of his death.)

June 26. — Appetite good ; pulse full and strong.

June 27. — He felt sick in the morning. About seven o'clock *some hemorrhage* from the wound occurred, which was arrested by compressing the common carotid artery. At nine o'clock he had a *convulsion and died.*

Post-mortem Examination. — The ball had passed into the chest, having *laid the internal jugular vein open for about four inches,* and fractured the transverse processes of the third and fourth cervical vertebræ. The tissues of the right side of the neck were infiltrated with pus.

Internal jugular vein wounded.

The Army Medical Museum also contains two specimens which belong to the same category as the foregoing case : one of them is " a wet preparation of a portion of the right

Two specimens of wounds of

[1] Vide pp. 10, 11 of this essay.

internal jugular vein, wounded by a round bullet from a spherical case (shot). A part of the parietes of the vein has been carried away, and in the posterior portion an orifice is seen, through which the contributor considers the missile passed. Private H. O., 'A,' 5th U. S. Artillery, Suffolk, Va., 15th April; died 19th April, 1863." The other specimen is "a wet preparation of a portion of the right internal jugular vein, after secondary hemorrhage from gunshot. The specimen shows the point of sloughing, and is occupied by a coagulum two inches below the orifice. Private S. W. S., 'B,' 1st N. Y. Dragoons, 23; ball entered two inches below and to the right of the superior angle of the scapula, passed through the neck and fractured the inferior maxilla, Spottsylvania C. H., Va., 8th May; admitted to hospital, Alexandria, Va., 24th; secondary hemorrhage, arrested by persulphate of iron, 27th May, 1864; date of death not reported." [1]

internal jugular in U. S. Army Medical Museum.

Case XLVI. *Gunshot Wound of the Femoral Vein; Death Seventeen Days afterwards from Exhaustion produced mainly by Hemorrhage, which frequently recurred;* this case was contributed by Dr. C. A. Leale, late Acting Assistant Surgeon U. S. Army. — David Wilson, private, Co. F, 110th Ohio Volunteers, age 44, was wounded in battle at Fort Stedman, March 25, 1865, by a *minie ball, which entered his right thigh,* at the middle of the sartorius border of Scarpa's triangle, and *cutting across the femoral vein,* passed beneath the ramus of the pubes, fracturing it, posterior to the perinæum; it then lodged, deeply imbedded in the glutei muscles.

Wound of femoral vein.

Hemorrhage continually took place, which at times was checked by styptics. He was admitted to Armory Square U. S. Army General Hospital March 28th; was then delirious. *His limb was infiltrated with serum from obstructed blood-flow in the femoral vein.* He died April 11th, of asthenia.

Post-mortem Examination. — The osseous parts along the passage made by the ball were very much comminuted; the wounded vein was partly closed by the inflammatory process, and filled with emboli.

The Army Medical Museum contains two specimens which were obtained from cases similar to the one just related: —

1st. "A wet preparation of the right femoral vein, showing an orifice from gunshot enlarged by sloughing. Private C. C., 'A,' 30th Iowa; bullet entered between the trochanter major of left femur and the apex of coccyx, cut the prostrate gland, and emerged one inch below Poupart's ligament, right side, Vicksburg,

Two similar specimens in Army Medical Museum.

[1] Vide *Catalogue*, p. 470, specimens Nos. 1055 and 2441.

22d May; admitted to hospital, Memphis, 27th May; died, exhausted from numerous small hemorrhages, 4th June, 1863." [1]

2d. "A wet preparation of the upper portion of the femoral vein, showing the point of sloughing after gunshot. The orifice is nearly opposite the mouth of the profunda. Private M. H., 'A,' 117th Ohio, 21; conoidal ball at short range passed directly through the inner part of thigh in its upper region, Covington, Ky., and admitted to hospital, Cincinnati, 1st April; venous hemorrhage 10th, 11th, and 13th; died 15th April, 1863." [2]

The surgical historian of the British army in the Crimean War, says: —

Crimean War experience.

"The principal lesions of the veins appear to have arisen much in the same manner as arterial injuries. That is, the mechanical causes have been similar; but on account of the different functions of the vessels, and the difference in the proneness to inflammation of their linings, and the greater tendency of the lining membrane of the venous system to take on the purulent form of inflammation, important practical differences arose, of which some mention may be made here. Thus, while we have seen the veins torn through, partially or completely, or their cavities secondarily opened by the separation of portions of their coats killed by the violence applied, or of sloughs formed as a consequence of unhealthy action set up in the wound, the effusion of any considerable or dangerous quantity of venous blood in wounds of the extremities, is not recorded." [3]

The same writer relates a case of gunshot fracture of the thigh in its upper third, and implicating the femoral vein, which terminated fatally in a few days, with symptoms of irritative fever: —

"On examination after death the femoral artery was intact, but the femoral vein had been wounded, and more than half its calibre shot away. There was, however, a wound of the profunda artery about two inches from its origin; the profunda vein was intact." [4]

Concerning the hemorrhage with which it was attended, he remarks: —

"Even in the case above related of Irvine, where half the calibre of the femoral vein was shot away, the venous hemorrhage would have been a source of but little trouble had it not been complicated with arterial bleeding from the wound of the profunda. The almost certainty of gangrene where the main artery and vein are both wounded has been noticed, and the influence of occlusion of the vein following

[1] Vide *Catalogue*, p. 471, specimen No. 2094.
[2] *Op. cit.*, p. 471, specimen No. 1093.
[3] *Op. cit.*, p. 344.
[4] *Op. cit.*, p. 341.

(not immediately, but after the lapse of some weeks), on the wound of an artery, shown." [1]

The Army Medical Museum contains the following specimens in which a gunshot lesion of an important artery is accompanied by corresponding wound of some important vein: —

1. "A wet preparation of portions of the left femoral artery and vein, wounded by gunshot. The artery, after death from pyæmia, was found completely severed, and occluded in both portions by firm clots. The vein was opened, and filled with pus (puriform matter) two inches above Poupart's ligament. Above that point, too, near the internal iliac, it was filled with a coagulum of lymph. Private E. H. C., 'I.' 26th Mass., 22; conoidal ball passed through fleshy part of left thigh, with severe hemorrhage, which ceased spontaneously; Winchester, 19th Sept.; died from pyæmia, 17th October, 1864." Both arteries and veins wounded. Army Med. Museum.

2. "A wet preparation of portions of the femoral vessels, wounded by gunshot. The femoral and profunda arteries are completely torn across an inch and a half below the origin of the profunda. The femoral and saphena veins are both torn near their junction. Private A. A. B., 'F,' 8th Illinois Cavalry, 20; wounded and tourniquet applied, Williamsport, Md., 7th July; admitted to hospital, with instrument still in position, Frederick, 8th; died from mortification of limb, 9th July, 1863."

3. "A wet preparation of portions of the right popliteal artery and vein, partially divided by a bullet. Corporal T. K., 2d U. S. Cavalry, 24; wounded 7th May; admitted to hospital, with aneurismal thrill, Washington, 11th; amputated in lowest third of thigh, 14th May; died from pyæmia 4th June, 1864." [2]

No case of *incised or lacerated wound* of a large vein has been brought to the author's notice.

The Army Medical Museum, however, contains a specimen of *punctured wound* of such a vessel. It consists of "a wet preparation of the left femoral vein pierced by a darning-needle. Private B. A., 'A.' 5th Iowa, 40; a conoidal ball passed through Scarpa's triangle without directly injuring the blood-vessel, Vicksburg, 19th May; admitted to hospital, with wound in a sloughing condition, Memphis, 27th; hemorrhage, checked by compression, 31st May; wound opened and needle extracted from the sheath, 2 P. M.; artery ligated for secondary hemorrhage, 8 P. M.; died 11 P. M., 1st June, 1863." [3] Punctured wound of femoral vein.

Wounds of veins constitute a subject of considerable importance

[1] *Op. cit.*, p. 344.

[2] Vide *Catalogue*, pp. 456, 457, Nos. 3794, 3959, 3579.

[3] Vide *Catalogue*, p. 472, specimen No. 2020.

to the surgeon: 1st, because they sometimes prove fatal by hemorrhage, if the wounded vessel be a large one; 2d, because they occasionally produce death by admitting or introducing atmospheric air into the circulating blood; and 3d, because they sometimes occasion a diffuse inflammation, so called, of the internal coat of the injured vessel, or extensive *thrombosis*, whereby life is speedily destroyed.

Certain forms of venous compression promote venous hemorrhage.

The flow of blood from wounded veins is always increased by pressure applied to the vessel on the proximal side of the wound, that is, between it and the heart; occasioned, for example, externally, by the application of a ligature or a roller bandage, or the pressure of tight clothing; occasioned, internally, by swollen lymphatic glands, or by tumefaction of any kind, that compresses the wounded vein on the side next the heart.

Muscular contractions also favor the production of venous hemorrhage in the limbs, because of the compression which they exert upon the wounded vein.

Posture, as influencing venous hemorrhage.

A depending position of the wounded part, whereby the blood in the vessels gravitates towards the hole in the vein, also increases the flow of blood in such cases. The author has often observed this fact in amputating the thigh. On raising up the stump the hemorrhage from the femoral vein generally ceases. On depressing it again the bleeding may return.

How to control the bleeding.

Treatment of Hemorrhage from Wounded Veins. — We should endeavor to restrain such bleeding by placing the wounded part in such a position as does not favor the determination of blood to it by the laws of gravity, that is, it should generally be placed in an elevated position. We should also see that the flow of blood from the wounded part towards the heart, is not obstructed by any form of external pressure, such as might be made by tight clothing, by a tourniquet, or by a roller bandage improperly applied. We should also employ a moderate amount of pressure over the wound itself, by means of graduated compresses, and if the lesion is situated in an extremity, the whole of the limb below the place of injury should be moderately supported by a roller bandage evenly applied from the toes or fingers upwards, according to the extremity which is injured, for the purpose of avoiding stagnation of blood and tumefaction of such part from the compression applied at the wound. At the same time quietude should be enjoined. When these means fi

to restrain the hemorrhage, the bleeding orifice of the wounded vessel should be closed by ligature. When such veins as the femoral, or the axillary, or the internal jugular are laid open, it is generally important to preserve the continuity of their canal if possible; and hence an effort should be made, in all cases that admit of it, to draw together the lips of the orifice in the vessel with a forceps, and include them in a ligature applied on the side of the vein. I have seen this proceeding adopted with success in a case where the internal jugular vein happened to be wounded while removing a deep-seated tumor of the neck. No difficulty ensued, and the patient made a good recovery. I have applied ligatures to wounded veins for the purpose of arresting hemorrhage in a considerable number of instances, consisting of stumps of amputated limbs, and operations upon the neck and armpit performed for various purposes, without ever observing any bad consequences. Dr. S. W. Gross has recently shown, in a very able and exhaustive paper on the wounds of the internal jugular vein and their treatment, that the apprehension of danger from tying veins is for the most part groundless, or at least that the risk is very much exaggerated.[1] To that paper the reader who desires further information on this subject, is respectfully referred.

The author's experience in tying veins.

Dr. S. W. Gross' valuable paper on the same.

Gunshot wounds of the femoral or the popliteal veins, when complicated with corresponding lesion of the femoral or the popliteal arteries, should generally be treated by immediate amputation, because death from hemorrhage, or consecutive gangrene, or blood-poisoning, is almost certain to ensue with but little delay, unless that expedient is employed. Indeed, unless immediate amputation is practiced, there is but very small prospect of saving such cases.[2] There is another very interesting specimen in that museum (or rather two specimens that are in reality but one), which strongly corroborates the views just expressed. These preparations consist of the left femoral artery and vein which have been severed by a small-arms projectile, just below the origin of the profunda, and subsequently tied for the relief of an aneurismal swelling. Private D. R., "K.," 7th Indiana, aged 20; wounded November 30th; bullet passed from behind directly through the left thigh,

Accidents which generally require immediate amputation.

Dr. W. Thomson's case.

[1] Vide *American Journal Med. Sciences*, January and April, 1867.

[2] See case of Gross, No. XII., Mr. Guthrie's cases, referred to on p. 77, the Crimean war case mentioned on p. 140, and the specimens belonging to our Army Medical Museum, which are cited on p. 141.

dividing both femoral artery and vein, and escaping in Scarpa's space; admitted to hospital, Washington, December 6th; operated on December 9th, by Assistant Surgeon William Thomson, because the aneurismal condition was increasing; he laid the tumor freely open, and thus found that there was free communication between the artery and the vein in the sac; he then tied, 1st, the proximal end of the femoral vein near the entrance of the saphena, because it bled profusely; 2d, the proximal part of the femoral artery below the origin of the profunda; 3d, the femoral artery two inches from its distal extremity; and 4th, the femoral vein near its distal extremity, to control an accidental hemorrhage; mortification of the limb followed, and death occurred December 13th, 1863. The writer saw this case in consultation with Dr. Thomson, and witnessed the operation. His condition was so low that amputation was believed to be out of the question. He was also very pale, and looked as if he had recently lost a large quantity of blood. The limb was already much tumefied and œdematous, and was growing worse. The aneurismal swelling was likely soon to burst. His general condition was likewise failing. The operation was therefore one of expediency, but fully justifiable, under the circumstances.[1] Primary amputation might have been followed by a better result.

[1] Vide *Catalogue*, pp. 462, 472, specimens 2249, 2250.

CHAPTER SIXTH.

ON ARTERIO-VENOUS ANEURISM.

An Illustrative Case related. — Another Case illustrating this Subject, which was contributed by Dr. David Prince. — Wound of the Left Carotid Artery and Jugular Vein, inflicted by a Pistol-bullet, producing Aneurism immediately and Varix subsequently; the Carotid was tied Seven Days after the Injury, and Cerebral Symptoms were induced thereby; Death occurred Five Days afterwards; Autopsy. — Dr. Prince's Comments on this Case. — How the Blood-supply of the Brain was diminished. — Consequences of the Diminished Blood-supply of the Brain. — A Case mentioned by Guthrie illustrates the same Subject. — Another Case illustrating the same Subject. — Mr. C. H. Moore on the same Subject. — On the Inutility of the Hunterian Operation for the Cure of Arterio-venous Aneurism.

A REMARKABLE case of this affection is reported in the "American Journal of the Medical Sciences," for October, 1865, p. 391 *et seq.*

CASE XLVII. — George Clark, private, 4th New Jersey Volunteers, a large muscular man, in vigorous health, whose average weight was 200 lbs., accidentally wounded himself with the large blade of a pocket-knife in the inner side of the left thigh, about two inches below Poupart's ligament, the blade entering the femoral artery and vein near the origin of the profunda.

Wound of femoral artery and vein.

He recovered rapidly, and resumed his usual occupation (that of a farmer) in a week after the receipt of the injury. He never experienced any pain or difficulty after his recovery, except a pricking pain at the wounded point upon unusual or excessive walking, until August, 1863 (eight years after the receipt of the original wound), when being in the army, his limb suddenly swelled so as to measure thirty-two inches in circumference, as the result of hardship and a long, fatiguing march. The patient was transferred in a few days to the Depôt Field Hospital, at Warrenton, Va., where he suffered excruciating pain in the inner side of his thigh, directly over his former wound; this pain continued two or three days without intermission. From this hospital he was sent to Washington, D. C., and thence to the U. S. Army General Hospital at Newark, New Jersey.

When admitted, the whole limb was greatly enlarged, with remarkable distension of the cutaneous veins.

February 6, 1864. — Dr. James B. Cutter, of Newark, N. J., tied his external iliac artery with great and immediate benefit. The performance of the operation was not attended with any difficulty, except an enormous amount of *superficial venous hemorrhage.* The patient made a good recovery, the ligature coming away on the 25th day.

But the relief was not permanent. In the following June the limb began to swell, and the superficial veins became enlarged again. At the close of August the thigh measured thirty-seven inches in circumference at its largest part, and the superficial veins were more distended than before the first operation.

September 17. — Dr. Cutter tied his common iliac artery as a measure of last resort. It was immediately followed by great diminution in the size of the limb, but the patient died five days afterwards of peritonitis.

I have omitted to state in the proper place that, prior to the first operation, the aneurismal bruit and aneurismal thrill were distinctly perceptible at the seat of the original wound.

At the *autopsy* a foramen of communication between the femoral artery and vein was found near the origin of the profunda, *the vein was very much enlarged, while below the point of communication the artery was considerably diminished in size.* The case seems in reality to have been one of *Aneurismal Varix.*

Dr. David Prince's case.

Dr. David Prince, of Jacksonville, Illinois, has contributed the following account, with a drawing, of a very interesting case of arterio-venous aneurism, involving the carotid artery and internal jugular vein, which was occasioned by a gun-shot wound. Together with the narrative, we lay before the reader all of Dr. Prince's notes and comments upon this case.

FIG. No. 1.

DR. DAVID PRINCE'S CASE OF ARTERIO-VENOUS ANEURISM.

A Nelaton's probe enters the opening one inch from the median line, and follows the track of the bullet, which took a small piece from the side of the carotid artery, and perforated the jugular vein, lodging finally under the skin at the back of the neck.

CASE XLVIII. *Wound of the Left Carotid Artery and Jugular Vein, inflicted by a Pistol-bullet, producing Aneurism immediately, and Varix subsequently. — The Aneurism bled Seven Days from the time of the Injury, and the Carotid was then tied below. — Impairment of the Cerebral Functions greatest on the Affected Side as to the Face, and on the Opposite Side as to the Parts below, commenced and continued till Death Five Days later, and Twelve Days from the Time of the Injury. — Upon the Autopsy it was found that the Consistence of the Corpus Striatum and the Optic Thalamus of the Affected Side was diminished.* — October 21, 1864, William Sloan, aged about 20, Co. F, 146th Illinois Volunteers, shot himself in the neck with a Smith and Wesson pistol, which, as he stooped over, fell out of his side pocket, and striking its hammer against a piece of iron, went off. The bullet entered the left side of the neck an inch from the median line, and on a level with the prominence of the thyroid cartilage (pomum Adami).

Half an hour after the accident there was considerable swelling behind the wound, the bleeding having already ceased. On introducing a probe the blood flowed freely, and the probing was therefore stopped, when the blood again ceased to flow.

October 28. — Seven days from the receipt of injury. Amount of swelling not great; a very distinct thrill, perceptible to the touch, and a loud whizzing murmur heard through the stethoscope.

Pressure upon the carotid artery in the lower portion of the neck diminished the thrill and the murmur, rendering it certain that the supply of blood must be through the carotid.

A hard movable substance was felt behind, just below the inferior transverse line of the occipital bone upon the left side, which was subsequently found to be the bullet. The bifurcation of the carotid artery would be in a line between these two points.

October 29. — Eight days from injury. The wound bled slightly in the night; applied a ligature to the carotid in its lower portion.

The thrill and the murmur could still be perceived in all parts of the tumor, though greatly diminished in intensity.

The pulse, before the application of the ligature, had been of usual frequency, but it had not been noted down.

On recovering from the effects of the combination of ether and chloroform administered, the pulse continued at sixty, the patient being very drowsy.

October 30. — Ninth day from injury and second from operation, morning. Has slept the greater part of the time; has no intelligence when he is aroused; pulse sixty; vomited once in the night; has taken some milk and some coffee.

Opens the left eyelids less than the right, and raises the left portion of the upper lip higher than the right.

Evening. Condition in all respects the same, sleeping most of the time, but peevish when aroused.

October 31. — The same in all respects.

November 1. — Eleventh day from injury and third from operation. Pulse sixty, morning, and fifty-six, evening; bowels moved from three fluiddrachms of senna; intelligent, knows what is said in his hearing; is unable to articulate or to protrude his tongue; his attempts to make known his wants in words amount only to whines scarcely intelligible. It is observed that there is a partial paralysis of motion and of sensibility in the right extremities. The sole of the right foot is insensible to tickling, while tickling the sole of the left foot induces immediate withdrawal. The palm of the right hand, however, is slightly sensitive to tickling.

The appetite has returned, and he readily eats what is given him.

Slight thrill and murmur perceived in the tumor.

November 2. — Pulse fifty. Has ate freely when aroused for that purpose. It has not been seen at any time that either of the pupils was dilated or contracted beyond the ordinary degree.

About noon a sweat came upon the right half of the body and *not* upon the left.

November 3. — Patient died at three A. M., twelve and a half days from the time of the injury, and on the beginning of the fifth day from the operation.

Autopsy. — The ligature was easily pulled away, cutting across the artery; but the surrounding new-formed tissue had acquired great firmness, holding the adjoining portions of the artery in position. A continuity of new-formed reddish material existed in the loose areolar tissue, anterior to the vessels and between the sterno mastoid on the outside, and the sterno hyoid, sterno thyroid, and the thyroid gland on the inner side.

Opposite the orifice in the skin made by the bullet, the tissue, new and old, presented a round canal, which gave them the appearance, when partially dissected, of a perforated artery.

Behind this the carotid artery was found, with a notch upon its outer side exactly opposite the bifurcation; and at a slightly higher point, the bullet had perforated the jugular vein, and had passed on through the deep muscles of the neck, lodging superficially.

No distinct aneurismal sac had formed, anteriorily or laterally, the infiltrated tissues presenting a solid mass, with the color ordinarily existing in lymphatic ganglia. Behind, a distinct clot was inclosed in a boundary of a considerable degree of distinctness, in the posterior portion of which the little bullet was found.

The internal carotid artery was traced up into the brain, with reference to the possible existence of a clot, but none was found. The sigmoid portion of the artery, upon the side of the body of the sphenoid bone, was full of liquid blood, and seemed larger than the corresponding portion of the artery of the other side, but no clot was found either here or in the course of the branches of the carotid within the cranium.

The veins in the brain and in its membranes were everywhere full of blood.

The substance of the corpus callosum and optic thalamus seemed softer upon the affected (left) side than upon the opposite.

Nothing abnormal was found elsewhere.

Considerations, by Dr. Prince. — The supply of blood to the left side of the brain had been diminished, not only by the ligature upon the common carotid artery, but a drain from the whole brain had been actually established, through the circle of Willis, by the returning current down the internal carotid to enter the jugular vein, through the new-formed varix, made by the passage of the bullet, which had opened both these vessels in immediate proximity to each other. While this condition must necessarily have interfered with the nutrition of the portions of the brain directly supplied by the internal carotid artery of the left side, the downward current must have favored the escape of blood through the circle of Willis from all the cerebral arteries, diminishing arterial tension, and thus interfering with the nutrition, as well as the functions of the whole brain, and producing death by the want of sufficient blood in the cerebrum for the performance of its functions, while the medulla oblongata, spinal cord, and all the other organs of the body, continued to have an adequate supply, presenting the unique condition of the cerebrum bled to death, while yet the general system retained its usual vascular supply.

Dr. Prince's comments. Blood-supply of the brain diminished.

Consequences of the diminished blood supply.

A few notes, also by Dr. Prince, are appended, of cases in which functional or organic lesions of the brain have followed interruption to an adequate supply of blood.

Guthrie[1] quotes from Velpeau a case in which the common carotid was first tied and then the internal, on account of an aneurismal tumor of the temple. The tumor diminished in size, but hemorrhage came from the upper opening of the common carotid, having descended the external carotid, and the patient died hemiplegic. Velpeau says he ought to have tied the external carotid also.

Guthrie's case.

A case of brain-softening following secondary hemorrhage from the internal carotid, so free as to produce extreme prostration, occurred during the late War of the Rebellion. The supply of blood to the brain through the carotid of the affected side, had previously been interrupted by a clot, which had formed above the injury of the artery, on account of which a slough had occurred, permitting an escape of blood from below; patient dying six days after ligature, and fifteen days from the injury.

Softening of brain from loss of blood. Another case.

A soldier at Tullahoma received, November 27, 1863, a gunshot

[1] *Commentaries*, Lond. ed., 1855, p. 254.

comminuted fracture of the right lower jaw, the wound extending into the neck. The wound suppurated freely, and nine days afterward an exhausting hemorrhage occurred from a slough in the internal carotid artery, throwing the patient into convulsions. The bleeding was arrested by pressing into the wound lint saturated with a solution of persulphate of iron, and the common carotid was immediately tied by Dr. Benjamin Woodward, Surgeon Illinois Volunteers, assisted by Dr. Pierce, Assistant Surgeon of the 150th N. Y. Volunteers. Morphia was then given in quarter grain doses every hour until the patient slept, and after that brandy and beef juice.

From an imperceptible pulse and a gasping breathing, the patient rallied, the pulse passing from a frequency of one hundred and twenty to ninety-eight in a minute.

Six days from the bleeding and fifteen from the date of injury, the pulse rose to one hundred and twenty, with listlessness of demeanor and hebetude of mind, feeble respiration, slight divergence of the right eye, anorexia, and death.

Autopsy. — Every portion of the surface of the dura mater was found covered with lymph, while serum lined the inner surface. The brain substance was more pallid upon the right side than upon the left.

A slough of half the circumference of the carotid, and half an inch in length, was found just beneath its entrance into the carotid foramen. The artery was occluded by a clot above the place of sloughing, and also upon both sides of the ligature.

There can be no doubt of the connection of the cerebral lesion with deficient supply of blood, while in the state of extreme want of arterial tension in the cerebral substance of the right side from the cutting off of its chief supply had commenced the series of changes which would, if life had been more prolonged, have resulted in white softening.

Upon this subject C. H. Moore, Esq., Surgeon to the Middlesex Hospital, London,[1] speaking of gangrene as a result of ligature of arteries, says of the brain after ligature of the carotid artery, "Gangrene shows itself principally in the form of softening of the brain. The external parts of the head and neck are never, as it seems, affected with gangrene, a fact which is readily accounted for by the liberal supply and free anastomosis of the vessels of the face and neck. The anastomoses in the brain are indeed even more abundant, but then the brain appears to be more in want of an equable and constant supply, and to tolerate badly the withdrawal, even for a short time, of so large a quantity of blood as is brought by the carotid artery. Twelve of the fifty-four cases in Dr. Norris' table seem to have died from some symptoms referable to the brain, which, however, are very variously stated — convulsions, apoplexy, and inflammation of the brain being the more common headings. It may be allowed us to doubt, in the

Mr. Moore on same subject.

[1] *Holmes' Surgery*, vol. iii., p. 498.

absence of more exact information, whether this inflammation was not, in most cases at any rate, atrophic softening."

The history of these two cases of arterio-venous aneurism goes to show the inutility of the Hunterian operation for the cure of that disorder. Both of them, however, are interesting and important in other respects, which it is scarcely necessary to consume further time in pointing out.

Inutility of Hunterian operation for arterio-venous aneurism.

CHAPTER SEVENTH.

ON WOUNDS OF THE HEART.

Penetrating Wounds of the Heart do not always prove speedily fatal. — Dupuytren's Cases referred to. — One of them survived the Injury several Hours. — Another Twenty-five Days. — Another Three Days. — Another Eight Days. — And Another died on the Twelfth Day. — Effect of Acupuncture of the Heart in Cases of Cholera. — That Gunshot Wounds of the Heart are not always immediately fatal is proved by the Surgical Experience of the Late War. — Four Specimens of this Lesion preserved in our Army Medical Museum. — But generally Gunshot Wounds of the Heart prove quickly fatal. — An Illustrative Case. — Gunshot Wound perforating the Aorta near its Origin, and the Right Auricle of the Heart; Death was instantly produced; Autopsy. — An Illustrative Case which occurred in the Practice of Prof. Carnochan. — Penetrating Gunshot Wound of the Heart; Life protracted for Eleven Days; Bullet found embedded and encysted in the Substance of the Heart at the Septum Ventriculorum; Wound of Heart healed; Death resulted from Pericarditis. — Dr. Purple's Monograph on Wounds of the Heart referred to. — It contains a Summary of Twelve Cases of Gunshot Injury of that Organ, in which the Patients survived from Forty-four Hours to Six Years. — A Case of Punctured Wound of the Base of the Right Ventricle of the Heart inflicted with the Blade of a Pocket-knife; Death on the Seventeenth Day from Pneumonia; Wound of the Heart closed; Report of the Case communicated to Prof. Hamilton by Dr. J. P. Wallace, late Acting Assisting Surgeon U. S. Army. — Punctured Wounds of the Heart usually prove quickly fatal, but generally not quite so quickly as Gunshot Wounds of that Organ. — Dr. Eve mentions Two Cases of Punctured Wounds of the Heart in which Recovery took place. — No Case of Heart-wound was treated in the British Army during the Crimean War.

PENETRATING wounds of the heart, occurring in the human subject, generally prove fatal, either instantly, or after the lapse of a very brief space of time. But these wounds of the great central organ for the circulation of the blood, *do not, in all cases, thus quickly destroy the lives of their victims.* For example, Dupuytren has given a detailed account of three cases which he had seen, wherein life was prolonged for a period varying from several hours to twenty-five days. Case I. was that of the Duc de Berri, who was assassinated, as he was leaving the opera, with a dagger, which traversed the right auricle of the heart. He survived several hours. Case II. was that of a man, aged 40, and laboring under a suicidal monomania, who attempted self-destruction by cutting off his penis close to its root, and by wounding both ventricles of his heart with a saddler's needle. He lived twenty-five days. Case III. was that of a man, aged 30, who stabbed himself in the precordial region in such a

Penetrating wounds of heart not always speedily fatal.

Dupuytren's cases. One survived several hours.

Twenty-five days.

Three days.

way as to penetrate the left ventricle of the heart, three times. He did not die till three days afterwards.

Dupuytren also says: "In my lectures on gunshot wounds, I have narrated the case of a man named Géray, in whom the left ventricle of the heart was pierced to the extent of three and a half lines; but who, nevertheless, survived for eight days, and would probably have recovered, had not softening of the left hemisphere of the brain supervened." He also mentions a case of laceration of the pericardium, accompanied by penetrating wound of the right ventricle of the heart, occasioned by a fragment of a fractured sternum, wherein death did not ensue until the twelfth day.

Eight days.

Died on the twelfth day.

Furthermore, he remarks that Mr. Searle tried acupuncture of the heart, at Warsaw, in cases of cholera; and the introduction of the needle was accompanied by scarcely any pain, and followed neither by extravasation of blood, nor inflammation.[1]

Acupuncture of heart in cases of cholera.

That even gunshot wounds of the heart are not always instantly fatal has been abundantly proved by the experience of American surgeons, especially during the recent war. It is stated in Circular No. 6 that, "four cases are recorded of gunshot wounds of the heart, that came under treatment. The specimens from these four cases are preserved in the Army Medical Museum. The patient that lived longest after a gunshot wound of the heart, survived twelve hours. In this case a small pistol-shot entered the left ventricle, and passed out through the right auricle." [2]

Experience of late war.

Four specimens in Army Med. Museum.

But the reader should not forget that in a very large majority of the cases of gunshot wounds of the heart, the patient dies either instantly or nearly so; and that the prolongation of life, under such circumstances, is a matter of unfrequent occurrence.

Generally prove quickly fatal.

The following case, which occurred in the author's practice, affords an example of what usually happens when the heart has been traversed by a gunshot projectile.

Case XLIX. *Gunshot Wound perforating the Aorta near its Origin, and the Right Auricle of the Heart; Death was instantly produced; Autopsy.* — On the morning of June 20th, a middle-aged man, named

[1] Vide Dupuytren on *Lesions of the Vascular System*, etc., p. 105 *et seq.*, London, 1854, Sydenham Soc. ed.

[2] Vide *Circular* No. 6, p. 25.

John Scully, was accidentally shot in the chest, with a Colt's navy revolver, which was in the hands of a pawnbroker, to whom he had offered it as a pledge, with the statement that it was not loaded. He was standing up in front of and facing the pawnbroker when the wound was inflicted, and instantly fell down dead.

A little after twelve o'clock, noon, the author made an autopsy. There was a gunshot wound, such as would be made by a pistol-bullet, upon his breast, to the left of the median line, near where the cartilage of the third rib is joined to the sternum. Some blood was flowing from the wound. On exploring the track of said wound it was found that it passed through said cartilage, that it grazed the anterior margin of the left lung, that it perforated the aorta near the semilunar valves, that it also perforated the right auricle of the heart, and passing onwards, became lost. The pericardium was filled with coagulated blood. There was a considerable quantity of extravasated blood in the pleural cavities. The course of the ball appears to have been altered somewhat by grazing the lung. It seems to have been reflected downwards and to the right thereby.

Ball perforated aorta and right auricle.

In the next case a pistol-ball buried itself in the muscular substance of the heart, where it became encysted, and the wound over it united. The patient died after eleven days, of pericarditis.

Prof. Carnochan's case.

CASE L. *Penetrating Gunshot Wound of the Heart; Life protracted for Eleven Days; Bullet found embedded and encysted in the Substance of the Heart at the Septum Ventriculorum; Wound of Heart healed; Death resulted from Pericarditis;* case reported by Prof. Carnochan. — On the 27th of February, 1855, I was called in consultation to see William Poole, aged 33 years, of unusually athletic form and muscular development, who had been wounded two days previously in an affray with fire-arms. He had received a bullet-wound in the outer aspect of the right thigh, two inches above the upper border of the patella. The wound, however, which created alarm among his friends, was situated upon the anterior wall of the thorax, about three quarters of an inch to the left of the mesial line, and about half an inch below a line drawn across the chest, from one nipple to the other. A bullet probe could be passed slantingly from right to left, along the track of the wound, for about an inch. At this depth, the probe was arrested, and it was not thought expedient to use force in making further exploration. Poole received his wounds during a deliberate onslaught made on him by some five or six persons, armed with Colt's revolvers. The first ball took effect on his right thigh, and brought him to the ground. While thus prostrate, another assailant placed the muzzle of a pistol close to his chest, and discharged its contents. He immediately jumped up, and reeling towards a door, rested, as if stunned, against it for sup-

Wm. Poole.

port, during some minutes. He then fell, exclaiming that he was dying, and remained senseless, cold, almost pulseless, and apparently moribund, for about four hours. From this condition he rallied, and became so free from the usual symptoms of severe injury, that his medical adviser, Dr. Putnam, considered that the ball had really not penetrated into the thoracic cavity, and my opinion was sought to corroborate or dispel this favorable view of the case.

I found him sitting up in bed, his back resting on pillows as a support, apparently at ease, and conversing with numerous acquaintances, who had come to visit him. His countenance exhibited no expression of anxiety, and he answered placidly and without effort the questions I put to him. His pulse was eighty, the respiration easy, the surface of the body normal in temperature and moist. The stethoscope revealed the existence of no difficulty in the respiratory passages, and the normal *Tick-Tac* of the heart beat with healthy precision. There were no signs of inflammation or of effusion into the pericardium.

With such freedom from morbid symptoms, I was disposed to concur with his medical adviser in auguring favorably of the case; for although it might be inferred from the external character of the wound, that the ball had passed somewhere into the cavity of the chest, it was not impossible that it had become lodged in some position where it remained innocuous.

Absence of symptoms of heart wounds.

The previous treatment had been gently antiphlogistic; mild aperients, diaphoretics, acidulated drinks, and low diet. The consultation resulted in the continuation of a similar mode of treatment, with the injunction that he should be kept in a state of absolute bodily rest, and free from every cause of mental excitement, as I felt far from certain that he had not sustained mortal injury.

The symptoms in Poole's case illustrate in a remarkable degree some of the peculiarities of wounds of the heart, and also the assertion made by Harvey, that the heart is not very sensible. I am informed by Dr. Putnam, who saw him at one o'clock on the morning of the 25th, about fifteen minutes after the wound was received, that the patient was at first nearly pulseless, was insensible, and that respiration was performed with great difficulty. In this condition, laboring also under the ordinary signs of shock to the system from a gunshot wound, he continued for about four hours, before any signs of reaction were manifested. Vomiting now occurred; this was followed by increased action of the heart, and sensibility gradually returned.

During the same day (25th) he continued improving, and on the evening visit, the pulse beat eighty-four. The skin was moist and natural, tongue healthy, with no unfavorable symptoms otherwise. No external hemorrhage had occurred from the wound, nor had any evidences of internal hemorrhage been evinced by vomiting or expectoration.

Monday, 26. — The wound was examined more particularly, and no

traces of the bullet could be found, nor any special indications manifested of its presence in the cavity of the thorax. Symptoms about the same.

Tuesday, 27. — I saw the patient for the first time, and found him in the favorable condition already stated.

Wednesday, 28. — Complained of slight headache; pulse eighty-six; bowels not having been moved, a gentle aperient was ordered, by which the pain in the head was relieved. At times the patient complained of transient and slight pain about the region of the heart.

Thursday, March 1. — Was called in to see patient a second time. Had slept well; pulse eighty; respiration natural; appetite good; skin moist; action of the heart natural. He stated that he felt no pain or unpleasant symptom except weakness, remarking, however, that he felt well enough to go out.

Friday, 2. — The patient perfectly comfortable; pulse eighty-two.

Saturday, 3. — Patient so well that, upon visiting him, for the third time, by request, he was found receiving his friends, and, contrary to previous injunctions, conversing freely with them. Enjoined repose.

Sunday, 4. — No untoward sign connected with either the functions of circulation or respiration. During the day he received, against positive orders, the visits of more than a hundred people, with whom he conversed. His own statement was that he felt quite well.

Monday, 5. — Dr. Putnam was sent for early in the morning. At eight o'clock, A. M., the patient was found in a high state of irritability; pulse one hundred and twenty; skin hot and dry, and complains of pain generally; respiration troubled and more frequent. An aperient was ordered, by which the symptoms were much alleviated.

Tuesday, 6. — Was again requested to see patient. Pulse one hundred; countenance anxious; the adnatao tinged yellow; complained of debility, but said he had no pain about the heart; signs of effusion.

Wednesday, 7. — Passed a restless night, notwithstanding the administration of an anodyne; pulse one hundred and twenty; countenance more anxious; respiration much troubled; inability to remain in the recumbent posture; symptoms gradually becoming more grave.

At two o'clock, Thursday morning, his attending physician was sent for. The patient was now rapidly sinking; pulse almost imperceptible, and with difficulty counted; respiration short, frequent, and difficult; extremities cold; countenance pallid and hippocratic. From this time he continued to sink, and expired, without a struggle, at five o'clock.

Died after eleven days.

Autopsy seven hours after death. — The body was in a state of perfect preservation, and showed a powerful and well-developed organization.

The surface of the body presented three orifices of gunshot wounds; two on the external side of the thigh, a short distance above the patella, by which, apparently, a ball had made its entrance

Autopsy.

and exit, respectively; and one on the anterior aspect of the chest, three quarters of an inch to the left of the median line, and about half an inch below a line drawn across the chest from one nipple to the other. The examination revealed that all the organs of the body were in a healthy condition.

The sternum and cartilages of the ribs having been partially elevated, a bullet probe could be passed without difficulty, slanting from right to left, through the wall of the thorax, at the place of junction of the cartilages of the fifth and sixth ribs with the margin of the sternum.

The sternum being completely elevated, the pericardium was seen to be much distended, and on its surface, in continuation with the external wound, was observed a rough spot, which proved to be an opening into the cavity of the pericardium, thinly closed by the exudation of plastic material.

The right and left cavities of the pleura were free from effusion, and the lung on each side was in a sound condition. The pericardium was found filled with serous fluid, tinged with blood, and was so much distended that it encroached very much upon the lungs on both sides. Upon opening the sac of the pericardium, and removing a large quantity of serous fluid, the external surface of the heart and the serous lining of the pericardium were both found to be entirely covered with plastic exudation, presenting all over signs of high inflammatory action. A cursory examination of the heart in position did not disclose the presence of any foreign body. It was afterwards taken out, and upon a careful examination, a bullet one inch in circumference was found enveloped in a delicate cyst, and embedded, to the depth of a quarter of an inch, in the muscular tissue of the septum, between the right and left ventricles, about midway between the apex of the heart and the base of the ventricles. Its locality was only indicated by the sense of touch, for as the wound had entirely cicatrized, there was no outward visible sign of its presence. Obviously, the cause of death was inflammation of the pericardium and heart, and its results.

Bullet in septum, between ventricles.

This case is one to be added to the few already on authentic record, showing that penetrating wounds of the heart are not always immediately mortal.

It has, moreover, peculiar features which will render it remarkable in the annals of surgical pathology.

Several cases are mentioned in which patients have survived one or more days the effects of penetrating and non-penetrating wounds of the heart, inflicted by cutting instruments, and also of non-penetrating wounds inflicted by *gunshot*.

But the peculiarity of this case is, that although the wound was a penetrating gunshot wound, leaving the ball deeply buried in

the tissue of the heart, the patient survived for a period of time so long as to encourage the hope of recovery.

Latour's case.

The position of the ball discriminates the case from that mentioned by the French surgeon, Latour, where the ball had not penetrated deeply into the heart, but rested on its surface, partially encroaching upon the muscular wall of the heart, and enfolded partly by the pericardium.

The autopsy of this case also revealed that the wound of the heart was not only closed and cicatrized, but that a cyst was in process of formation around the ball.

By this case, also, it is established, that hemorrhage is not necessarily a consequence of a gunshot wound of the heart; for the serum found in the pericardium was merely tinged with blood,

Absence of hemorrhage.

and there was no coagulum. The absence of hemorrhage may be accounted for by the conical shape of the ball, and by its direction, two circumstances which favored its passage between the muscular fibres of the superficial layer of the heart, without severing them, and caused it to rest slantingly behind the anterior coronary artery, without wounding it.[1]

Dr. Purple's monograph. Twelve cases. Survived from forty hours to six years.

Dr. S. S. Purple, of New York, in an excellent monograph on "Wounds of the Heart," has furnished a résumé of twelve cases of *gunshot injuries* of this organ, in which the patients survived the accident a considerable length of time, the periods ranging from forty-four hours to six years. In one of these examples, the patient having died on the sixty-seventh day, three shot were found lying loose in the right ventricle, and two in the right auricle. The wounds had cicatrized. Another man is declared to have lived ten weeks with a musket ball in the cavity of the left ventricle. The patient reported by Malle, lived forty-seven days with a piece of wood transfixing the left ventricle and projecting fairly into the right; and Davis has recorded a similar case, the result of a gunshot accident also, in which a stick, three inches long, remained thirty-seven days in the right ventricle before it caused death.[2]

CASE LI. *Punctured Wound of the Base of the Right Ventricle of the Heart, inflicted with the Blade of a Pocket-knife; Death on the Seventeenth Day from Pneumonia; Wound of the Heart closed;* report of the case communicated to Prof. Hamilton by Dr. J. P. Wallace, late Acting Assistant Surgeon U. S. Army. — In February, 1865, private ——

1 Vide *American Medical Monthly*, April 1855. The foregoing account of this interesting case has been considerably abridged from Prof. Carnochan's excellent report of it.

2 Vide *N. Y. Journal of Medicine*, May 1855; also Hamilton's *Military Surgery*, p. 263.

Walker, a police detective for Brigadier-general Speed S. Fry, commanding post at Camp Nelson, Ky., became engaged in a quarrel with one Joseph Nichols of that place, which resulted in the stabbing of the former between the third and fourth ribs, near the sternum. The wound was aimed to be inflicted on the jugular vein, but owing to the sudden spring backwards, by way of avoiding the knife, that point was missed, and the thorax received the weapon.

The instrument used was a pocket-knife, the blade of which was about three inches long, quite narrow, and slightly curved at the point. He fell instantly, and exclaimed, "I am stabbed." Stabbed with a pocket-knife.

He was carried to a house near by, and surgical aid summoned. He was found by Acting Assistant Surgeon H——, greatly excited and very restless. His countenance was pale, and expressive of deep anxiety. The respiration was hurried, and the pulse scarcely to be counted. Some pain existed in the vicinity of the wound. As an evidence of fright, his bed and body were completely besmeared with fæces, involuntarily passed at the time of receiving the wound.

The length of the wound was about half an inch. There was but little hemorrhage, no more than would ordinarily result from a flesh wound of the same dimensions.

The following morning I saw the case with Drs. H. and R., and found him in a condition but little changed from that of the evening previous. The anxious expression of his countenance was particularly marked. He was constantly tossing from side to side in his bed, and when asked if he suffered any pain, replied, "No, not much; but I have such a queer feeling here" (placing his hand, at the same time, over the region of the heart). The pulse was about the same as at the first visit, possibly not so frequent.

A stimulating treatment was recommended by Drs. H. and R., to which I dissented, believing depressent remedies more suitable. I was overruled, however, and brandy and paregoric were consequently administered at regular intervals. Anodynes were given at night to insure sleep. Pneumonia was rapidly developed in the left lung, and subsequently in the right.

On the fifth day, while auscultating the chest, a peculiar sound was observed in the immediate vicinity of the wound. It appeared as though there was fluid being forcibly thrown against the walls of the chest in a small stream. A peculiar whizzing sound was heard also. It was not as one continuous stream, but was distinctly interrupted. These interruptions were observed to occur with the relaxation of the heart, or, in other words, the pulsations were synchronous with the action of the heart. In a short time a small tumor was formed on the surface of the chest, not larger in diameter than the finger-nail. It was watched for several days with a mixed feeling of curiosity and fear. It was curious from its inexplicable nature,

Heart sound.

Pulsating tumor.

and fearful as to its results, for it was gradually growing larger, and the pulsations stronger.

Its regular pulsations, its fixed position, its peculiar thrill, its receding and returning as the hand is pressed upon or withdrawn from it, and its isochronous action with that of the heart, spoke boldly of its aneurismal nature; yet from what source this aneurism came, was a question which not a little exercised the minds of all present. Could it be from the ascending aorta, or from its arch? The relation of this vessel and the tumor would not admit of such a conclusion, the tumor being on the left side of the chest and below the origin of the aorta, whereas in aneurism of that vessel the tumor is felt on the right of the sternum, and above the position occupied by the present tumor. In the arch of the aorta it is felt in the neck, just above the manubrium. Again: was it a wound of the heart? The symptoms certainly pointed to such a diagnosis; but could we suppose the central organ of the circulation to have been penetrated and at every pulsation sending forth a jet of blood, and yet the patient continue to survive? This in itself looked unreasonable, and we were compelled to acknowledge our inability to unravel its hidden source.

Pneumonia.

During all this time the pneumonia had been rapidly progressing, and the left chest becoming filled with fluid. Dullness existed over the whole of the left side of the thorax. The heart was gradually becoming pushed to the right. Its sounds were now better heard beneath the sternum.

Disappearance of tumor.

On the ninth day the characteristic symptoms of the tumor were observed to be less marked. It was smaller, and the pulsations diminished in force. The tenth day showed evident signs of its rapid diminution, and the eleventh day announced its entire disappearance.

The effusion of fluids into the thoracic cavity of the left side was steadily becoming increased. The lung was very much compressed from its presence, as shown by the exceedingly difficult respiration. This no doubt was increased by the pneumonia of both lungs. The patient was much debilitated. The pulse was quite small and rather frequent. The pulsations were irregular, some stronger and fuller than others. Upon applying the hand over the heart, its action was observed to be labored, as though it was performing more work than was its habit. It was now distinctly heard and felt on the right of the sternum.

Died on seventeenth day.

This condition of things continued to exist until the seventeenth day, when the patient expired.

Autopsy. — The thorax was opened by separating the costal cartilages on the one side from the ribs, and turning the sternum downwards. Upon attempting to raise the sternum, however, a hindrance was encountered in the shape of a uniform adhesion of the pericardium, and pulmonary pleura, to nearly the whole length of the sternum. In the excessive inflammation present, the two membranes had become firmly

united, so that the heart was drawn in immediate apposition to the wall of the thorax. These adhesions were cut through, and the sternum raised. Upon the inner wall of the chest, between the third and fourth costal cartilages and hugging the sternum, was observed a depression, which, upon examination, was found to lie in a *seemingly* fibroid structure, of about three fourths of an inch in diameter. By introducing the handle of the scalpel between this body and the intercostal space, it was readily dislodged from its resting-place. It was of a concavo-convex shape, and had been cut through while engaged in severing the membranous adhesions from the sternum. At the same time, a wound of the right ventricle of the heart was seen near its base. By turning down the sternum, the depression in the third costal space was observed to exactly cover the wound of the heart. The wound on the exterior of the ventricle was yet ununited, and had the appearance of an old cut. This was plainly seen by making a fresh incision and comparing the two. A probe was then introduced into the wound, but it was soon obstructed. It would not pass into the wound by gentle pressure. Upon opening the ventricle there was but little, if any, appearance of a cicatrix. The heart was turned transversely to the right, and occupied a higher position than was natural. Clots of dark-colored blood were found in its cavities.

Wound of right ventricle.

The left lung was partially destroyed by inflammation, so much so that some of the medium-sized bronchi were seen projecting through the pulmonary tissue. The pleural cavity of this side was filled with a sero-sanguinolent fluid, mixed with pus. Indeed, it was so abundant as to cause the intercostal spaces — prior to death — to protrude beyond the level of the ribs.

Here, then, in the post-mortem examination, we had made clear to us what before death was a mystery. What then appeared as "in itself unreasonable," now was proved a reality. The pulsating tumor was caused by a wound of the heart communicating with the right ventricle. Although the wound did not, after death, extend entirely through the wall of the ventricle, yet, that it had previously done so, there could be no doubt. The correspondence in position of the wound of the heart and the pulsating tumor, the disappearance of the tumor six days previous to dissolution, the failure to find in the aorta or any of the smaller vessels a cause for the production of such a tumor, and the close proximity and fixed position of the heart to the sternum, definitely settled that point. The wound of the ventricle had, then, partially united. But how was this accomplished?

The knife, when it first entered the thorax, doubtless pierced a portion of the lung tissue which overlies the heart in front. This probably was the primary source of imflammation in that lung. The ejected blood from the wound of the heart was undoubtedly another source of inflammation, both to the lung and surrounding tissues. As the result

of this inflammation we have large collections of serum and lymph in the plural and pericardial cavities. By the mechanical pressure which would naturally result from this abnormal accumulation of fluid, the heart was pressed closely against the sternum, and the jet of blood directed against the third intercostal space close to the sternum. The continued force thus applied against the thoracic walls formed a concavity or protruding outward of its tissues [the pulsating tumor]. From the sides of this concavity sprung up new or adventitious tissue, which, by its gradual increase, formed a pouch or cul-de-sac. This gradually completely surrounded the wound of the heart, so that the blood, finding no outlet, formed a coagulum in the pouch, and thus prevented the flow of any more blood from the wound. The passage of blood through the wound being stopped, we had security of a speedy union, inasmuch as it prevented the washing away of any lymph that might be poured out upon the edges of the wound.

We may say the wound was closed as a result of the excessive inflammation of the surrounding tissues. It was the result of this inflammation that produced the death of the patient; hence what produced a cure in the one case, produced a death in the other.

P. S. — I had charge of this case from the time of the disappearance of the tumor.

J. P. WALLACE, M. D.

Punctured wounds of the heart are, like gunshot wounds of this organ, in most cases quickly fatal; but death as the result of these injuries is generally not quite so immediate, and a few examples are recorded of final and complete recovery.[1]

In Eve's "Collection of Remarkable Cases in Surgery," an instance is mentioned in which the heart was penetrated by a fractured rib. The subject lived more than an hour. In another case the heart was transfixed by a sharp stilet, and death did not occur till twenty days afterwards. In another case the heart was transfixed with a darning-needle, thrust in for suicidal purposes. The needle was extracted, and the patient recovered. In another case a stab-wound was inflicted in the left breast with a pocket-knife, which appears to have penetrated the right ventricle. This patient recovered.[2]

Eve's two cases of recovery.

Dr. Purple, in his paper on "Wounds of the Heart," already referred to, has collected thirty examples of punctured wounds of that organ. Two of them survived twenty-five days.

Purple has collected thirty cases of punctured wounds of heart. Two survived twenty-five days.

When Poole's case was before the New York Pathological So-

[1] Vide Hamilton's *Military Surgery*, pp. 315, 316.

[2] *Op. cit.*, pp. 219, 220, 221, 222.

ciety, Prof. Clark referred to two instances on the records of the Society where the heart was pierced through by a sharp instrument, one patient living about thirty days, the other eleven days.

The surgical historian of the British Army in the Crimean War, says: —

"No case of wound of the heart is reported to have been under treatment, and if such occurred they were all fatal before medical attendance could be procured; at all events, none lived long enough to be admitted to hospital for treatment."[1]

No case of heart wound treated in British Army during Crimean War.

NOTE. — The editor will take the liberty of introducing here a report of a gunshot wound of the heart, which did not prove fatal until twenty years after the receipt of the injury. The heart, containing the ball, was presented to the writer by Dr. G. B. Balch, late Surgeon U. S. Volunteers, now a resident of Plattsburg, New York State; to whom the patient was well known for many years, and who carefully gathered the history of the case, after having witnessed his death and made the autopsy. The specimen was laid before the New York Pathological Society in 1867; and the report of the examination then made, with the remarks of several distinguished surgeons present, will be found in the New York *Medical Record* for March 1, 1867, p. 18. The heart, containing the ball, is still in possession of the writer, and can be seen at the Bellevue Hospital Medical College. It is, without doubt, the most remarkable case on record.

In the year 1840, John Kelly, then fourteen years of age, was employed at Chatham Four Corners, Columbia Co., N. Y., in driving a horse, his employers being engaged in the construction of a railroad from Albany to Boston.

One night while in bed in the upper part of a shanty, a target rifle, loaded with a round ball, was discharged from a hill back of the house. The ball passed through two roof boards and a board partition, entering Kelly's right shoulder through the border of the trapezius muscle, about two inches above the acromion process. Dr. Schufelt and two other physicians who were called, probed the wound, and thought they felt the ball about four inches from the point of entrance, the direction of the track being downwards and a little inwards. They decided, however, that it was not prudent to attempt its removal.

There was but little hemorrhage, and "no great local disturbance at the time." In about six weeks he was able to resume his work, and at this time seemed perfectly well. He subsequently removed to Clinton Co., N. Y., married, and became the father of several children.

In 1845 he was attacked with acute pneumonia of the upper lobe of the right lung, and fell under the care of Dr. Orville Terry, of Bedford, Clinton Co., N. Y. There was now for the first time noticed a very tumultuous action of his heart, which remained after his recovery from the pneumonia, and continued to increase to the time of his death, fifteen years later.

In June of 1860 he was seized with congestion — so called — of his right lung, induced by exposure in the cold waters of a mountain brook, into which he had gone for the purpose of washing sheep. The heart's action became now exceedingly violent. Two days before his death his right hand and arm became purple and cold; and four or five days after this attack commenced he died, on the 14th of June, 1860. During this last illness he was under the charge of Dr. Terry.

It was well understood that he had carried this ball twenty years, and the autopsy was made chiefly for the purpose of finding it.

Dr. Balch, who made the autopsy, reports: "I found the right internal jugular vein enlarged, but I could not find the right external jugular. I however discovered what I supposed to be the remains of this vein, terminating in the internal jugular (which is an

[1] *Op. cit.*, p. 326.

anomaly in that vein). In the right subclavian artery, pericardium, and in other places, there were atheromatous deposits. The upper lobe of the right lung was congested; other parts of the lungs normal. No tubercles. The heart was enlarged, soft, and flabby, having undergone Quain's fatty degeneration. The pericardium was very adherent, more particularly on the right side. As yet no ball had been found. A hard lump was now felt in the right ventricle, near the apex of the heart. On introducing my finger into the ventricle through the vena cava and right auricle, I ascertained that the lump was in the wall of the right ventricle, near the septum, at the most depending part of the ventricle. Looking carefully at the outer surface of the organ, no cicatrix could be seen. I then cut down upon the lump, and found it to be a leaden bullet, somewhat flattened, and encysted in the wall of the heart."

At the time of the presentation of this specimen to the Pathological Society, a question arose as to how and when this ball entered the heart. By some gentlemen it was thought to have entered by the way of some of the large veins. This opinion has been verified by a later and more careful examination. The ball, no doubt, lodged originally against the right subclavian artery, near the inner edge of the anterior scalenus. From thence it made its way by absorption, gradually, into the right subclavian artery, forming a small aneurismal sac; and from this point it slowly travelled, by pressure and absorption, into the internal jugular vein. The ball must have reached the internal jugular vein about five years after it entered the body, and at the time when he was first seized with violent palpitation of the heart, accompanied with pneumonia. The ball probably dropped at once to the apex of the right ventricle, and possibly soon became entangled under or between the columnæ carnæ, so that it was not thrown about by the ventricular contractions; and from thence it finally entered the walls of the heart.

The reasons why the above explanation of the manner in which the ball gained access to the heart has been adopted are the following: —

First. The direction and depth of the original wound would indicate that it lodged near the right subclavian artery.

Second. The absence of any serious hemorrhage indicates that it did not at once enter the artery. And the absence of any cardiac symptoms at this time, and for the five following years, demonstrates that it did not, during that period, enter the heart. Moreover, there was no cicatrix in the pericardium opposite the situation of the ball, and no appearance of cicatricial tissue in the outer wall of the heart, underneath which the ball was found.

Third. The right external jugular vein could not be found by Dr. Balch, and the examination of the specimen shows that the right subclavian vein is obliterated near the point of its entrance into the right vena innominata; both of which phenomena were probably the results of long continued pressure.

Fourth. The aneurismal sac in the right subclavian artery, large enough to contain about half an ounce of blood, and a considerable portion of the walls of which had undergone the atheromatous degeneration, presented on one side an almost complete supplemental sac, communicating, however, freely with the main sac, of about the size of the ball, and the walls of which were much thicker; and in addition to having undergone the atheromatous degeneration, they had become in some measure calcified. This supplemental sac I believe to have been the original seat of lodgment of the ball.

Fifth. The inner wall of the aneurismal sac, and the outer wall of the right internal jugular vein were in contact, and an opening large enough to allow of the passage of the ball existed between the sac and the vein.

Sixth. The inner wall of the heart, where it covered the ball, had lost the appearance of muscular tissue, and was white and condensed like fibrous tissue. On the outer surface, opposite the ball, as I have already stated, no such change had occurred. The situation of the ball, as it still lies imbedded in the walls of the heart, is a little nearer the inner than the outer surface.

CHAPTER EIGHTH.

ON THE SPONTANEOUS ARREST OF HEMORRHAGE FROM WOUNDED ARTERIES, AND THE MEANS BY WHICH IT IS EFFECTED.

Mr. Paget's Remarks on Hemorrhage from Incised Wounds. — It occurs mostly in Distinct and Visible Streams. — Nearly all the Minute Vessels become closed as soon as divided. — How such Closure is effected. — Gradually the Larger Vessels also cease to bleed. — The Subsequent Phenomena. — The Spontaneous Arrest of the Bleeding from a Severed Artery is effected by the Following Means: 1st. Constriction or even Closure of the Bleeding Orifice by Contraction of the Fibres of the Muscular Coat at the Place of Injury. — 2d. Retraction of the Ends of the Severed Artery; its Consequences. — How this Retraction is effected. — 3d. Coagulation of the Outflowing Blood, whereby first an *External* and second an *Internal* Coagulum or Plug is formed. — The Coagulability of the Blood increases rapidly with the Approach of Syncope. — 4th. Diminution of the Force of the Heart's Contractions as the Loss of Blood increases. — Description of the Local Phenomena which are thus produced. — Guthrie's Remarks on the Phenomena relating to the Spontaneous Arrest of Arterial Hemorrhage. — Dr. Jones' Explanation differs somewhat from the Foregoing. — He gives Undue Prominence to Retraction. — Consequences of Retraction. — An Occluding Clot more readily retained in Situ. — Dr. Jones on the External Coagulum — also on the Internal Coagulum. — Dr. Jones on the Reparative Process in Wounds of Arteries. — Exudation of Plastic Material. — The Permanent Arrest of Bleeding chiefly depends on this Coagulum of Lymph. — Other Phenomena attending the Reparative Process in Wounds of Arteries. — The Permanent Suppression of Hemorrhage is effected by the Concurrent and Successive Operations of many Causes. — They are briefly enumerated. — The Arteries are much less likely to bleed when severed by a Lacerated Wound than by an Incised Wound. — The Reasons of this Difference briefly stated. — The Phenomena also briefly described. — Arteries possess *Extensibility* and *Elasticity* as well as Contractility and Retractility. — When the Occluding Clot is small or weak, it may give Rise to Intermediary Hemorrhage or Traumatic Aneurism. — The Bleeding from Wounded Arteries is much more likely to cease spontaneously when they are completely than when they are but partially severed. — The Reasons severally stated. —The Nature of the Injury of the Surrounding Parts often assists in arresting Hemorrhage. — Foreign Bodies in the Wound may also assist in producing the same Result. — A Musket-ball sometimes serves to repress Arterial Hemorrhage by occluding the Wound in the Artery itself. — Dr. Peters' Case referred to. — Dr. Gouley's Case related. — Secondary Hemorrhage from Left Carotid Artery, wounded Fourteen Days previously by a Musket-ball, which passed nearly through the Vessel and lodged in its Walls beneath the Omo-hyoid Muscle, and completely occluded it on the Cardiac Side of the Wound; a small Aneurism formed on the Distal Side of the Wound from which Profuse and Fatal Bleeding occurred. — A Remarkable Feature of this Case mentioned. — A Traumatic Aneurism formed in Connection with the Distal End of the Artery. — The Subject of Primary Hemorrhage has been considered in Connection with Wounds of the Arteries.

MR. PAGET, speaking of hemorrhage from incised wounds, says:—

"It might be supposed that at the moment after division, every vessel would bleed, with a stream equal to its own calibre; but when one watches how little, if any, blood flows from a wound except in distinct and visible streams, it seems evident that of the

Mr. Paget's remarks.

crowds of vessels that are seen in well-injected specimens of the tissues, nearly all must become closed during or immediately after their division. The mechanical irritation of the knife, probably, excites the muscular tissue of both arteries and veins to this contraction; and it is assisted, in open wounds, by the contact of the air; and in all wounds, by the release of many of the capillaries and veins from the pressure of the blood, which ceases to be supplied to them in full quantity, when the arteries related to them are divided. Whatever hinders this contraction of the vessels prolongs and increases the bleeding. Hence the occasionally large bleedings from comparatively small vessels traversing or connected with tough, close textures, such as the small arteries in or near the aponeuroses and fasciæ, or in the more compact parts of the skin, *e. g.* of the face. So, in inflamed parts, or in those near the seats of active disease, the dilated vessels bleed largely and long when divided, because of the loss of contractile power in their muscular coats.

How closure of minute vessels is effected.

"Gradually, with or without surgical help, all vessels divided by a wound are closed and cease to bleed; the larger being often aided to this end by their retraction among the looser textures, and by the coagulation of the blood within or over their orifices, and by the diminution of the heart's force with the increasing loss of blood. Coincidently, the flowing blood becomes gradually brighter and paler. And, if the wound be left open, after pure blood has ceased to flow, there is an oozing of blood-tinged, serous-looking fluid; and this is gradually succeeded by a paler fluid, some of which collects, like a whitish film or glazing, on the surface of the wound. It contains very numerous white blood-cells, imbedded, apparently, in a fibrinous film."[1]

The larger vessels.

From the foregoing statement it appears that the spontaneous arrest of the hemorrhage from a divided artery is effected by the coincident operation of a considerable number of distinct agencies, which are the following: —

Spontaneous arrest of bleeding.

1st. The *contraction* of the artery at the place of division, the consequence of which is, that its orifice is either closed completely, a circumstance that generally occurs to the small vessels when severed, or, on the other hand, becomes very much diminished in size, a result which is not unfrequently witnessed in the large arteries when they are completely divided. This diminution in the size of a bleeding orifice produced by the severance of an artery, is occasioned directly by the contraction of the muscular tissue which belongs to its walls, and, in cases of wounds dividing the small vessels, is usually sufficient to completely stop the escape of the blood, while in cases of wounds dividing the

Contraction of the artery.

[1] Holmes' *System of Surgery*, vol. i. pp. 580, 581.

large vessels the stream of outflowing blood is considerably diminished in size thereby.

2d. The *retraction* of the ends of the severed artery into its sheath, or into the looser textures by which it is surrounded, whereby the escape of blood is rendered more difficult, assists materially in suppressing primary hemorrhage. This *retraction* is effected by the contraction of certain fibres belonging to the muscular tissue of the middle arterial tunic. It does not occur so quickly as the constriction of the orifice, in some instances at least.

Retraction of ends of severed artery.

3d. The *coagulation of the blood*, as it escapes from the divided vessel, in consequence of which the wound in the parts external to the vessel becomes filled up with coagulated blood (*external coagulum*), and, finally, a plug of clotted blood is formed in the vessel itself, at and within its orifice (*internal coagulum*), affords very important assistance in effecting the suppression of primary hemorrhage. The fact that the coagulability of the blood is markedly increased on the approach of syncope, is also a matter of practical importance.

Coagulation of the blood. *External* and *internal* coagulum.

4th. The *diminution of the force with which the heart contracts*, as the loss of blood increases, also exerts an important influence in arresting the flow of blood from an artery. "The forcible manner in which the jet of blood is propelled at each systole of the ventricle, is the principal obstacle to the coagulation of the blood around and within the cut vessel; for not only does the movement of the blood prevent coagulation, but so long as the jet is more powerful than the cohesion of the clot, it will certainly wash the coagulum away. As the blood flows, and the heart's impulse becomes gradually lessened in force, the jet becomes lower and lower, until at last, when faintness comes on, it is almost entirely arrested, and time is afforded for the formation and the deposit of a coagulum." (Erichsen.)

Diminution of force of heart's contractions.

With regard to the phenomena pertaining to the spontaneous arrest of primary hemorrhage, Mr. Guthrie says: —

"In many cases of amputation at the wrist and forearm, in which I wished the patient to lose a certain quantity of blood, I have allowed either the radial or ulnar artery to bleed until it ceased. At first, the jet appears interrupted, then the stream becomes continuous, although projected further at each systole of the heart. *As the orifice contracts*, the flow of blood becomes more equal, it is thrown to a less distance, the size of the stream is smaller, and it goes on

Guthrie's remarks.

diminishing until it only oozes out, and then soon ceases; the extremity of the vessel being covered by a layer of coagulum of greater or less thickness. The experiment may be made every day upon the temporal artery, with this addition, that as the stream diminishes let a fillip be given with the nail to the extremity of the vessel, when the jet will become a little larger; and this may be done several times, until at last it fails to have any effect, and the hemorrhage ceases. In none of these instances could the retraction of the artery be fairly estimated, although it appears from analogy, and from what is seen to occur in other cases, that a certain degree of it must have taken place. In similar cases, in which I have been able to make an examination either after death or amputation, the contraction of the vessel was evident, as well as the formation of a very slight external coagulum, extending into the canal of the artery. The sheath of the artery could do nothing, because there was none; neither did the internal coagulum, which, at this period, strictly speaking, does not exist. In small vessels, such as the radial or ulnar arteries, I do not believe anything depends on the diminished power of the circulation; but when the axillary or femoral arteries are divided, the shock of the injury, and the loss of blood, powerfully contribute to the suppression of hemorrhage."[1]

Dr. Jones' explanation.

Dr. Jones' account of the means by which primary hemorrhage is spontaneously arrested, differs somewhat from the foregoing, inasmuch as he gives special, and, perhaps, undue prominence to the retraction of the ends of the divided vessel. He says: —

"An impetuous flow of blood, a sudden and forcible retraction of the artery within its sheath, and a slight contraction of its extremity, are the immediate and almost simultaneous effects of its division. The natural impulse, however, with which the blood is driven on, in some measure counteracts the retraction, and resists the contraction of the artery. The blood is effused into the cellular substance between the artery and its sheath, and, passing through that canal of the sheath which has been formed by the retraction of the artery, flows freely externally, or is extravasated into the surrounding cellular membrane, in proportion to the open or confined state of the external wound. The retracting artery leaves the internal surface of the sheath uneven by lacerating or stretching the cellular fibres that connected them. These fibres entangle the blood as it flows, and thus the foundation is laid for the formation of a coagulum at the mouth of the artery, and which appears to be completed by the blood, as it passes through this canal of the sheath, gradually adhering and coagulating around its internal surface, till it completely fills it up from the circumference to the centre.

Occluding clot more readily retained.

[1] Guthrie on *Diseases and Injuries of Arteries*, pp. 225, 226.

"A certain degree of obstruction to the hemorrhage, which results from the effusion of blood into the surrounding cellular membrane, and between the artery and its sheath, but particularly the diminished force and velocity of the circulation, occasioned by the hemorrhage, and the speedy coagulation of the blood, which is a well known consequence of such diminished action of the vascular system, most essentially contribute to the accomplishment of this important and desirable effect.

"A coagulum, then, formed at the mouth of the artery, and within its sheath, and which I have distinguished in the experiments by the name of the *external coagulum*, presents the first complete barrier to the effusion of blood. This coagulum, viewed externally, appears like a continuation of the artery; its termination can be distinctly seen with the coagulum completely shutting up its mouth, and inclosed in its sheath. Dr. Jones on external coagulum.

"The mouth of the artery being no longer pervious, nor a collateral branch very near it, the blood just within it is at rest, coagulates, and forms, in general, a slender conical coagulum, which neither fills up the canal of the artery, nor adheres to its sides, except by a small portion of the circumference of its base, which lies near the extremity of the vessel. This coagulum is distinct from the former, and I have called it the *internal coagulum*. Dr. Jones on internal coagulum.

"In the mean time *the cut extremity of the artery inflames*, and the vasa vasorum pour out lymph, which is prevented from escaping by the external coagulum. This lymph fills up the extremity of the artery, is situated between the internal and external coagula of blood, is somewhat intermingled with them, or adheres to them, and is firmly united all round to the internal coat of the artery. Dr. Jones on reparative process.

"*The permanent suppression of the hemorrhage chiefly depends on this coagulum of lymph;* but while it is forming within, the extremity of the artery is further secured by a gradual contraction which it undergoes, and by an effusion of lymph between its tunics and into the cellular membrane surrounding it; in consequence of which these parts become thickened, and so completely incorporated with each other that it is impossible to distinguish one from the other; thus not only is the canal of the artery obliterated, but its extremity also is completely effaced, and blended with the surrounding parts. Permanent arrest of bleeding.

"When the wound in the integuments is not healed by the first intention, coagulating lymph, which is soon effused, not only attaches the artery firmly to the subjacent and lateral parts, but also gives it a new covering, and completely excludes it from the external wound, which then goes on to fill up and heal in the usual manner.

"The circumstances now described are observed also in the inferior portion of the artery, or that which is supplied with blood by anastomosis; with this difference only, that its orifice is generally more contracted, and the external coagulum is much smaller than the one which

adheres to the mouth of the superior portion of the artery, or that from which the blood flows in its direct course from the heart.

"From this view of the subject we can no longer consider the suppression of hemorrhage as a simple or mere mechanical effect, but as a process performed by the concurrent and successive operations of many causes; these may briefly be stated to consist in the retraction and contraction of the artery; the formation of a coagulum at its mouth; the inflammation and consolidation of its extremity by an effusion of coagulating lymph within its canal, between its tunics, and in the cellular substance surrounding it." [1]

The foregoing observations and remarks concerning the spontaneous suppression of primary hemorrhage have been founded exclusively on cases wherein the vessel was completely divided by a cutting instrument, or, in other words, had been severed by an incised wound. Now, it is well known that when arteries are torn across by lacerated wounds, as they not unfrequently are from avulsion of limbs by machinery, etc., there is very much less bleeding than there is when the same vessels are severed by incised wounds. Indeed, in cases where limbs are torn off by machinery the loss of blood is usually small. In such cases there is but little hemorrhage, because the internal and middle coats of the arteries are broken off short, while the external coat and sheath of these vessels are dragged down and twisted over the torn ends of the arteries in such a way as to afford a ready lodgment for a coagulum having the nature of a plug. This happens in such arteries as the brachial, the axillary, and the femoral. They are seen hanging out of the wound, and pulsating down to their very end, which is usually contracted to a point, the hemorrhage, at the same time, being completely suppressed. It may also be generally seen, in such cases, that, with every pulsation, the end of the severed vessel is thrust still further downward, but recoils again during the interval between the pulsations. This fact proves that *arteries* are endowed with *extensibility* and *elasticity*. We have already seen that they are possessed of *contractility* and *retractility*.

Incised and lacerated wounds of arteries.

Arteries possess extensibility and elasticity.

When the coagulating blood does not succeed in plugging up the bleeding orifice in the severed artery, until the occurrence of syncope, it may happen, that when reaction takes place the hemorrhage will return; or, at a later date, a traumatic aneurism may be formed.

Occluding clot small or weak.

[1] Dr. Jones on *Hemorrhage*, p. 53 *et seq.* London, 1805.

It is not difficult to understand why hemorrhage is much more likely to cease spontaneously when arteries are completely than when they are but partially divided. In the latter case the injured part of the artery cannot contract in such a way as to diminish the size of the bleeding orifice; but, on the contrary, the contraction of the muscular coat itself generally causes the aperture in the walls of the artery to gape open, and thus the size of the bleeding orifice is usually increased instead of being diminished, when the artery is but partially divided. Again, the injured part o the artery cannot be retracted within the sheath in cases of partial division to anything like the same extent as in cases of complete division, and thus the external coagulum is much less likely to present a successful resistance to the escape of blood from the wounded vessel in the former than in the latter case. Furthermore, when the wound of an artery is in the nature of partial division, an internal coagulum cannot be spontaneously formed. The continuity of the vessel being still preserved in a greater or less degree, but corresponding with the extent to which its walls are divided, the blood within the calibre of the artery is not allowed to stagnate sufficiently for coagulation to occur. It continues to flow through or past the orifice in the arterial walls in a wave-like stream. Under such circumstances the formation of an internal coagulum is generally out of the question.

Complete or partial section.

It should also be stated that great assistance is sometimes afforded by the surrounding soft parts in effecting the arrest of hemorrhage from a wounded artery. If, for example, the aperture in them happens to be valvular, an excellent support to the external coagulum is afforded thereby. If the track of the wound be narrow and ragged, and oblique in its direction, it will assist materially in maintaining the position of the external coagulum.

Injury of surrounding parts.

Again: a foreign body, such as a piece of clothing, when carried by the projectile into the track of the wound, may, for a time assist considerably in suppressing the hemorrhage, by assisting to keep the external coagulum *in situ*, an occurrence which was witnessed in Case No. VIII.

Foreign bodies in wound.

Furthermore: a foreign body, such as a musket-ball, may serve to repress hemorrhage from a wounded artery, by plugging up the orifice in the vessel itself. Thus, in a case reported by Dr. Dewitt C. Peters, U. S. A., in the "American Journal Med. Sciences," April 1865, pp. 373, 374, the right vertebral artery was extensively lacerated by a gunshot pro-

Ball occluding the wound. Dr. Peters' case.

jectile, at the point where it passes through the foramen of the transverse process of the atlas, *and the ball resting there probably acted as a plug, and in that way restrained hemorrhage from said vessel.*

Dr. Gouley's case.

The following case, which is related with considerable fullness, is a very singular and interesting one, wherein the common carotid artery was divided and at the same time plugged up by a ball, in such a way as to effectually prevent any primary hemorrhage from it.

Case LII. *Secondary Hemorrhage from Left Carotid Artery, wounded Fourteen Days previously by a Musket-ball, which passed nearly through the Vessel and lodged in its walls beneath the Omo-hyoid Muscle, and completely occluded it on the Cardiac Side of the Wound; a small Aneurism formed on the Distal Side of the Wound, from which Profuse and Fatal Bleeding occurred. — August* 15, 1861. At the Washington Infirmary, through the kindness of Dr. J. W. S. Gouley, then attached to the Medical Service of the U. S. Army, the author had an opportunity to examine a very interesting preparation of the left common carotid artery, and the parts adjacent to it, which had been obtained, on the previous day, at the autopsy of a soldier who had died from secondary hemorrhage following a gunshot wound of the left side of the face and neck. The ball, which, by the way, was nearly spent, struck the lower jaw, well forward, and was deflected downward, backwards, and a little outwards, in such a manner as to pass obliquely through the left common carotid artery, and to lodge in the tunics and sheath of that vessel underneath the omo-hyoid muscle, pressing somewhat upon the par vagum, and *occluding completely the proximal end of the divided artery.* It was a round ball. The hemorrhage occurred *fourteen days* after the wound was inflicted, and two or three days after his admission into the Infirmary. It came on suddenly without warning, and was very profuse. The patient lost more than a quart of blood, which flowed in a great stream from his mouth. On the supposition that the hemorrhage proceeded from a lesion of some of the carotid vessels, an effort was made to tie the common carotid above the omo-hyoid muscle, but it had to be abandoned on account of the great profuseness of a flow of blood which took place in the wound of operation, and did not permit the search to be continued in order to secure the bleeding vessel by ligature at the place of injury. It was believed by all the surgeons present that the patient was now so much exhausted by the loss of blood as to make it useless to attempt to tie the common carotid artery below the omo-hyoid muscle; and the next morning he died. Moreover, the source of the hemorrhage was very obscure until it was revealed at the autopsy. *It was then found that the divided carotid artery was still occluded on the side of the wound towards the heart* (*proximal*) *by the*

impacted ball; that a false aneurism as large as a filbert and elongated in shape had been formed at the distal extremity and on the inner side of the wounded artery, just above the omo-hyoid muscle; that the hemorrhage occurred from rupture or spontaneous opening of the sac of this traumatic aneurism; that the hemorrhage was not direct, but recurrent in character; and that it could not have been arrested without the application of a ligature to the vessel on the distal side of the wound in it. The ligation of the common carotid below the omo-hyoid muscle would, therefore, not have done any good, unless the vessel had been tied at the same time, at some point beyond the spot where it was wounded and where the traumatic aneurism was situated.

Traumatic aneurism upon distal end of artery.

A remarkable, and, so far as the writer knows, an unique feature of this case was, that the traumatic aneurism was formed in connection with the distal end of the divided common carotid artery, the occurrence of which appears to have been favored by the free anastomosis which exists between the terminal branches of both the external and internal carotid arteries of the two sides of the body.

Primary hemorrhage.

While considering, in a previous part of this essay, the various forms of injury to which the blood-vessels are subjected, such as the *punctured*, *contused*, *lacerated*, *gunshot*, and *incised wounds* of their walls, and among other consequences of these wounds the bleeding which generally attends their infliction, we have, in reality, been discussing the subject of *primary hemorrhage*. Thus, we have now considered this subject pretty thoroughly in respect to its nature, causes, phenomena, consequences, and treatment.

CHAPTER NINTH.

ON INTERMEDIARY HEMORRHAGE.

This Subject next claims our Attention. — We do not employ the Term in the same Sense as Dr. Macleod. — We restrict its Use to Hemorrhage occurring in the Intermediary Period, properly so called. — Definition of Term. — Intermediary Hemorrhage generally connected with Increased Vascular Activity. — It belongs to the Period of Reaction. — As the Intermediary Period is brief, so this Form of Bleeding occurs comparatively but seldom. — Four Examples of Intermediary Hemorrhage will be related. — One of them occurred in the Stump of a recently Amputated Thigh. — In Another Case the Bleeding occurred in an Arm-stump from the Ligature slipping off from the End of the Main Artery. — In the other Two Cases the Bleeding was produced by the Bursting open of Traumatic Orifices in Vessels but imperfectly closed with Coagula. — An Illustrative Case contributed by Dr. C. A. Leale. — Intermediary Hemorrhage, parenchymatous in Character, following Secondary Amputation, and arrested by the Application of Liquor Ferri Persulph.; Recovery. — Another Illustrative Case. — Intermediary Hemorrhage from an Arm-stump on the Fourth Day after Amputation, the Brachial Artery having not been properly tied; arrested by opening the Stump and tying the Artery again; its Coats were healthy; Death Thirteen Days afterwards from Pyæmia. — Another Illustrative Case. — Profuse Intermediary Hemorrhage from a Gunshot Wound of the Face and Neck: it occurred on the Fourth Day; Ligation of Right Primitive Carotid Artery; it recurred; Ligation of Left External Carotid; Recovery. — Another Illustrative Case. — Intermediary Hemorrhage from the Deep Palmar Arch following Gunshot Wound of Hand; it began on the Second Day; Ligation of Brachial Artery; more than Four Months afterwards the Hand was attacked with Sloughing; then Profuse Secondary Hemorrhage occurred; it was controlled by Styptics and Pressure. — Prof. Hamilton's Observations on Intermediary Hemorrhage. — The Pathology of this Form of Bleeding. — Intermediary Hemorrhage occurs more frequently than is generally supposed. — Its Disastrous Consequences. — On the Treatment of Intermediary Hemorrhage: 1st, with Styptics; 2d, by retying the Bleeding Vessel; 3d, by tying the Main Artery at some Distance from the Wound.

Interme diary Hemorrhage.

We propose next to briefly consider the subject of *intermediary hemorrhage*, and we intend to give some additional attention to it, because it has but seldom found a place in the systematic treatises on surgery.

Dr. Macleod's application of term.

We also wish to remark, at the outset, that we do not employ the term intermediary hemorrhage in the same sense that Dr. Macleod does. Speaking of hemorrhage, he says: "That which takes place after twenty-four hours and up to the tenth day, being usually due to sloughing, resulting directly from the injury, should always have the term 'intermediary' applied to it."[1] Now, it seems to the writer preferable to limit the use of the term "intermediary" to hemorrhage occurring in

[1] Vide *Notes on the Surgery of the Crimean War*, p. 130. Am. Ed.

the intermediary period, strictly so called, because, in the first place, it appears to be more philosophical to employ it in that way, and *because*, in the second place, such hemorrhage, according to the writer's experience, is *not* produced by sloughing, but by excited arterial action. Prof. Hamilton entertains the same views as the writer on this point.

The term intermediary hemorrhage, as already stated, embraces all the effusions of blood from wounds, or wounded vessels, which take place during the intermediary period, that is, subsequent to the occurrence of reaction, or at the end of the first twenty-four hours after the injury has been inflicted, and prior to the establishment of suppuration, on the fifth or sixth day. Definition of term.

Intermediary hemorrhage is, in most cases where it occurs, obviously connected with increased vascular action, and the increased force with which the blood is driven through the arteries, that obtains during the period of reaction and inflammatory irritation which follows the "shock" occasioned by the infliction of severe wounds, especially if they are accompanied by profuse primary hemorrhage, and precedes the advent of suppuration. As the intermediary period is brief in duration, so the number of cases of intermediary hemorrhage which comes to the surgeon's notice is small when compared with the number of cases of secondary hemorrhage which he is called upon to treat. Generally connected with increased vascular activity. Infrequency of.

In the following pages will be found an account of four cases of intermediary hemorrhage. One of them followed an amputation of the thigh, which was performed through inflamed tissues; and although twelve ligatures were applied at the operation to stanch the bleeding, the loss of contractile power on the part of the small vessels was so great (paralysis), that hemorrhage recurred from them when reaction took place. The loss of power in these small vessels to contract and close their mouths was occasioned by the preëxisting inflammation which had paralyzed their muscular coat. Four examples.

In another case, intermediary hemorrhage occurred in the stump of an arm which had been amputated, because the ligature slipped off from the brachial artery. It appears to have been carelessly applied near the end of the vessel, and also not tied with sufficient tightness. In consequence of this inexcusable negligence on the part of the surgeon who performed the amputation, the ligature was gradually pushed off from the end of the artery by its

pulsations, after reaction took place, and blood flowed from the mouth of the vessel into the stump.

In the remaining two cases the hemorrhage likewise occurred during the period of reaction and vascular excitement, and appears to have been occasioned by the bursting open of traumatic orifices in blood-vessels, which had previously been imperfectly plugged up with coagula, said reopening of these orifices being produced directly by the increased force of the arterial action. In these two cases the occluding clots appear to have been pushed away by the exalted force of the current of blood in the arteries.

Dr. Leale's case.

The following history of a case of intermediary hemorrhage was contributed by Dr. Charles A. Leale, late Acting Assistant Surgeon U. S. Army.

CASE LIII. *Intermediary Hemorrhage, Parenchymatous in Character, following Secondary Amputation of Thigh; Recovery.*— George R. Maxwell, Lieut.-Colonel 1st Mich. Cav.; age 22. Wounded at Five Forks, Va., by conical ball, April 1st, 1865.

The ball entered opposite head of fibula, opening the left knee-joint.

When admitted he was very anæmic; extensive suppuration had taken place; the pus was infiltrated between the muscles as high as the apex of Scarpa's triangle.

The joint was filled with pus, and the leg had become infiltrated with serum. His general condition was very unfavorable; gave him champagne and beef-tea every hour.

April 17.— No change in his condition. D. W. Bliss, Surgeon U. S. Vols., after the patient had been placed under the influence of ether, amputated the thigh by the circular operation, at middle third of femur.

The knee-joint was then found to be filled with pus, and the muscles had been separated by extensive abscesses, which extended to Scarpa's triangle.

The stump was dressed with cold water, and the patient was placed in bed, and took tinct. opii. f. ʒss, sp. vini Gall. f. ʒj, to be followed by sul. morph. and beef ext. every two hours.

April 18.— *Although twelve ligatures had been applied, hemorrhage has continued to take place (he is apparently of a hemorrhagic diathesis); has lost altogether about eight ounces of blood. Applied liq. ferri persulph. fortis* by a camel's-hair brush to the whole of the surface of the wound, which had been left open and exposed to the air for about fifteen minutes; this styptic entirely checked the sanguineous oozing.

April 20.— The granulations have become healthy, and about two drachms of pus are discharged daily.

April 30.— The wounds have granulated well, and the stump is nearly closed.

June 23. — Removed a fragment of necrosed femur, of conical shape, and about four inches in length.

August 4. — Patient left for home — stump solid and in good condition.

The following case occurred under the author's observation: —

Case LIV. *Intermediary Hemorrhage from Arm-stump on the Fourth Day after Amputation, the Brachial Artery having not been properly secured by Ligature; arrested by opening Stump and tying Artery again; its Coats were healthy; Death Thirteen Days afterwards from Pyæmia.* — Private John P. Fitzpatrick, Co. G, 52d N. Y. Vols., aged 37, sustained a gunshot fracture of his left humerus in the battle of Spottsylvania C. H., Va., May 18th, 1864, in consequence of which his arm was then amputated, at the junction of its middle and superior third, by the double-flap method.

On the 21st he was admitted to the Stanton U. S. Army General Hospital.

On the 22d, twelve hours after admission, he was attacked by profuse arterial hemorrhage from the stump. The dressings were immediately removed, the flaps opened, whereupon it was found that *the flow of blood proceeded from the brachial artery, which had not been properly secured by ligature in the first instance, or, at least, the ligature had slipped off from it.* The artery was then tied again upon the face of the stump, by Assistant Surgeon Geo. A. Mursick, U. S. Vols. Its coats appeared healthy. He lost about sixteen ounces of blood.

May 27. — The stump looked well, and the purulent matter discharged was healthy.

May 29 *and* 30. — He had pyæmic chills and other symptoms of the purulent infection.

June 4. — He exhibited symptoms of pyæmic pneumonia, and died the same day.

The hemorrhage did not return after the last operation, that is, the one performed on the day following his admission to hospital.

Case LV. *Profuse Intermediary Hemorrhage from a Gunshot Wound involving Face and Neck; it occurred on Fourth Day; Ligation of Right Primitive Carotid Artery; the Hemorrhage recurred; Ligation of Left External Carotid; Recovery.* — Dr. M. Mahon, Surgeon Ohio Vols., relates the case which occurred in the person of a soldier, aged 25, wounded at the storming of Mission Ridge, Nov. 25. Ball entered anterior to left angle of lower jaw, fracturing that bone, making a ragged opening nearly one inch long, passed downwards and to the right under the tongue, cutting the floor of the mouth, and escaped from the side of the neck to the right and a little below the great corner of the hyoid bone.

November 29. — Evening. Dr. M. was hastily called to this patient

on account of hemorrhage. The distance to the patient was about one square. Dr. M. found him bleeding from the right side, the blood rushing from his mouth, and the aperture where the ball escaped from his neck, in a continuous stream, which was bright arterial, and came, as was supposed, from the sublingual artery. He had already lost between three and four pints of blood (estimated).

It was at once decided to ligate the common carotid of the right side. The patient was placed in a semi-recumbent position, his back well supported by a nurse. It was utterly impossible for him to lie down; as it was, the blood flowed into his mouth with such rapidity as almost to cause strangulation. The administration of chloroform could not be entertained. The vessel was tied just above the omo-hyoid muscle. All hemorrhage immediately ceased. The time consumed was extremely short, as the operation, in order to be successful, had to be expeditiously performed. During the operation an assistant had to introduce his finger into the patient's mouth to free it from the clots of blood which interfered with respiration. In tightening the ligature, Dr. M. watched the patient's face to see if any effect would be produced, but none was visible except an expression of relief from the pain incidental to the operation. He was placed upon supporting treatment (nutrients and stimulants).

November 30. — No return of hemorrhage; had rested tolerably well; very much prostrated; pulse rapid and weak.

December 1. — Slight hemorrhage occurred from wounds on left side during night, controlled by liquor ferri persulphatis.

December 2. — Hemorrhage recurred both morning and evening.

December 3. — Last night about 12 M., hemorrhage occurred again with considerable force, which necessitated the ligation of the left external carotid. Afterwards the hemorrhage did not return.

December 4. — Patient very weak; pulse one hundred, small and feeble; appetite poor, cannot partake of solid food; has to subsist on liquids, beef-tea, farina, thin gruel, coffee, tea, and whiskey-toddy. Milk-punch he cannot bear.

December 6. — General condition somewhat improved, but he cannot sit up in bed without causing a feeling of faintness and dizziness. Pulsation can be felt on supra-orbital ridge of left side, but more distinctly on right side. Face blanched.

December 9. — Doing well; pulse ninety, tolerably strong, with considerable volume; appetite good. Expresses himself as doing well.

From this time he continued to improve. The ligature from the external carotid separated December 11; that from the primitive, the following day.

January 28, 1864. — This man left Chattanooga on furlough for his home in Indiana, to all appearance as well as ever, except the inconvenience of being unable to masticate his food.[1]

[1] Vide *American Journal Medical Sciences*, July, 1864, pp. 276–278.

CASE LVI. *Intermediary Hemorrhage from Deep Palmar Arch following Gunshot Wound of Hand; it began on the Second Day; Ligation of Brachial Artery; more than Four Months afterwards the Hand was attacked with Sloughing; then Profuse Secondary Hemorrhage occurred; it was controlled by Styptics and Pressure;* reported by Dr. James M. Holloway. — Isaac Herring, private 53d Regiment, Co. C; occupation farmer; aged 24 years; general health good; wounded at the battle of Missionary Ridge, November 25, 1863. Gunshot wound (minie) of left hand; ball entering palmar aspect between first and second metacarpal bones, near their carpal extremities, and lodging under the skin on the dorsum near the ulnar side of the metacarpo-phalangeal articulation of the thumb. The ball was extracted shortly after receipt of injury. He was sent to the rear by rail on the 28th, arriving at the hospital on the evening of the 29th. His wound commenced to bleed on the morning of the 27th at the field infirmary, and continued to bleed at intervals throughout the trip; and upon arrival at the hospital was nearly pulseless.

Diagnosis. — Intermediary hemorrhage from the deep palmar arch.

November 29. — *The brachial artery was ligated in its middle third* by Dr. H., and the wound in the hand was cleansed and carefully dressed. *The pulse at the wrist was felt beating full and strong eight hours afterwards.* Extensive inflammation of the whole hand followed, and was treated with cold applications. *The hemorrhage did not recur.* He was transferred to another post, forty miles distant, January 26, 1864. At that time the hand and fore-arm were still somewhat inflamed; pain severe; a deep-seated palmar abscess formed, and was opened; the wrist-joint had become anchylosed. He suffered from a mild attack of erysipelas, extending up the arm and over the face.

April 9. — Being possessed of a powerful constitution, he has been able to endure an unreasonable amount of suffering, and, at present, he is walking about his ward. The cicatrices in the hand have recently commenced to ulcerate, destroying the web between the index finger and thumb. His appetite is good. It may be remarked that the pain in the hand has been at times so severe as to resist all means employed for its mitigation, even the endermic application of large doses of morphia.

April 16. — The ulceration continues; a red line extends along the flexor aspect of the arm; hand œdematous; not painful upon pressure; ordered charcoal and cinchona poultice with a view to its cleansing and stimulant effect. Tension and long-standing inflammation of the tissues have destroyed their vitality.

April 20. — Ulceration has given place to sloughing, with constitutional disturbance. Surrounding tissues red, swollen, and sensitive. *Slight arterial hemorrhage occurred this morning.* Countenance anxious, and pulse irritable. Ordered nitric acid to wound, and large doses of tinct. ferri chlorid. and chlorate of potassa.

April 21. — Neglected to take iron and potassa yesterday; *another slight hemorrhage this morning;* cleaned wound of slough and clots, and *dressed with charpie steeped in turpentine;* it seems disposed to take on healthy action.

April 24. — *Hemorrhage recurred this morning at daylight, and was profuse;* again at 10 A. M. The slough has extended over the thumb, and invaded the metacarpo-phalangeal articulation. *Cleaned the wound, and filled it with persulphate of iron in powder. Applied a light retentive bandage, and elevated the hand.* Ordered opium, gr. i., to be repeated as often as necessary to secure rest.

April 29. — Healthy action has returned, and the wound is granulating. The persulphate of iron has formed a firm plug, and is being gradually loosened and pushed out.

May 1. — No more hemorrhage; wounds in good condition, and general health improving.[1]

Concerning intermediary hemorrhage Professor Hamilton observes: —

Prof. Hamilton's observations.

"Such hemorrhages are easily understood. They are the result of returning circulation, and if only moderate, and if proceeding only from small vessels, they will demand no special attention. In a few hours more the steady progress of the inflammation will entirely put an end to such slight oozings of blood. If, however, this bleeding is excessive, or if it proceeds from larger vessels, the surgeon must promptly find some means for its arrest. It may be that the limb is in a depending position, or a bandage may be maladjusted and producing ligation; but more often its cause will be found in the fact that the surgeon has omitted to secure some considerable artery; and if change of position, refrigerating mixtures, or well-applied pressure do not speedily succeed in its arrest, no time should be lost in removing the dressings, wiping away the clots, and securing the vessel with a ligature.

Frequent in military practice.

These intermediary hemorrhages are pretty frequent in military practice, and do not receive the attention they demand. If it were not that surgeons cannot always spare the time, when the number of wounded is very great, to make a very critical search for vessels which do not at first bleed, we would say that such bleedings implied culpable negligence on their part; but, however this may be, the omission to give it careful and prompt attention now, can only be excused on the ground of an extraordinary necessity. Some of these patients, left to themselves, bleed to death; but it more often happens that, in the hope of arresting the bleeding by pressure alone, or by cold applications perhaps, the surgeon intrusts the matter to an attendant, until the track of the wound and the adjacent structures become filled with coagula, which greatly increase the diffi-

Disastrous consequences.

[1] Vide *American Journal Medical Sciences*, Oct. 1865, pp. 341–342.

culty of subsequent ligation of the vessel; and which coagula, if the bleeding finally ceases, become depots for the formation of pus, thus greatly retarding the final cure. In the case of amputations made on the field, the same observations will apply. The intermediary hemorrhages lift the flaps, and prevent all possibility of immediate union. It is far better in such cases to reopen the wound, remove the clots, and tie the vessels; although it may be somewhat mortifying to the surgeon who made the original dressing, since it is apt to be construed into a reflection upon his skill."[1]

Treatment with styptics.

In addition to the foregoing judicious observations of Professor Hamilton concerning the surgical treatment required by the intermediary hemorrhage, it should be stated that in cases like No. LIII., wherein the bleeding was parenchymatous in character, it is advisable to open the stump, remove the coagula, and either paint the bleeding surface with liquor ferri persulph., or cover it over with lint saturated with that solution.

Retying the bleeding vessel.

In Case No. LIV. an illy applied ligature slipped off from the end of the brachial artery, and allowed intermediary hemorrhage to take place. It was arrested by opening the stump and reapplying the ligature, after which the bleeding did not return.

Tying the main artery.

In Case No. LV. a gunshot projectile passed through the throat, from side to side, wounding the floor of the mouth and the base of the tongue. Intermediary hemorrhage occurred from some of the branches of the lingual artery, as it was supposed. It was controlled by tying the right common carotid artery. Subsequently it recurred, and was again arrested by tying the left external carotid artery. Afterwards it did not return.

In Case No. LVI., a gunshot wound involving the deep palmar arch was followed by intermediary hemorrhage, which was permanently arrested by ligation of the brachial artery.

[1] Vide *Hamilton's Military Surgery*, pp. 213, 214. New York: 1865.

CHAPTER TENTH.

ON SECONDARY HEMORRHAGE.

Definition of the Term. — This Accident belongs to the Secondary Period and is connected with the Process of Suppuration. — It usually occurs between the Fifth and Twentieth Days; but most frequently about the Fourteenth Day. — Summary of Sixty-five Cases of Secondary Hemorrhage. — In Scorbutic Subjects Secondary Bleeding is most likely to occur on the Fifth, Sixth, and Seventh Days. — Causes of Secondary Hemorrhage. — It may be produced by a Considerable Variety of Causes, as follows: 1st. It is not unfrequently produced by a Contused Wound of an Artery. — An Illustrative Case contributed by Dr. Benjamin Woodward. — Gunshot Wound of Face and Neck with Comminuted Fracture of Lower Jaw on Right Side; very Profuse Hemorrhage on Seventh Day from Internal Carotid Artery which had sloughed; Ligation of Common Carotid; Bleeding permanently arrested; Death on Seventh Day afterwards from Meningitis and Softening of the Brain; Autopsy. — An Important Feature of this Case mentioned. — Another Important Feature of this Case. — 2d. Secondary Hemorrhage is sometimes produced by the Separation of the Slough, which not unfrequently surrounds the Track of Gunshot Projectiles, in the Soft Parts. — An Illustrative Case. — Secondary Hemorrhage following Gunshot Wound of Thigh (Flesh) on the Eleventh Day; Ligation of Femoral Artery on the Plan of Hunter; Consecutive Gangrene and Death on Eighteenth Day after the Wound was inflicted. — 3d. Secondary Hemorrhage often occurs in Consequence of the Walls of an Artery having been attacked by Sloughing at a Place where they were not primarily injured. — Sloughing Ulceration and Sloughing Phagedæna. — Three Cases illustrating this Form of Secondary Hemorrhage related. — Secondary Hemorrhage may be produced by Simple Ulceration. — An Illustrative Case of a very Interesting and Instructive Character. — Gunshot Wound of Ankle-joint involving the Tibia and Astragalus; Profuse Bleeding, Arterial in its Nature, occurred on the Eighty-fifth (85th) Day; Amputation; Dissection of the Amputated Member showed that the Posterior Tibial Artery had been opened by the Ulcerative Process from Pressure exerted by a Piece of Broken Bone; Death on the Twentieth Day after the Operation from Exhaustion. — Another Illustrative Case in which the Popliteal Artery was opened by Ulceration occasioned by a Sequestrum. — Two Additional Cases related in which Important Arteries were opened by the Ulcerative Process. — In both, the Ulceration of the Arterial Tunics appears to have resulted from a Depraved Condition of the General Health. — 5th. Secondary Hemorrhage is not unfrequently produced by the Non-union or Non-healing of Arteries when they are tied. — Case of Saxon referred to. — 6th. Secondary Hemorrhage is sometimes occasioned by the Liquefaction or the Giving Way of the Adhesive Material with which an Arterial Wound has been closed. — An Illustrative Case. — Secondary Hemorrhage from a Gunshot Wound of Leg severing the Peroneal Artery, with Fracture of the Fibula, occurring on the Fourteenth Day; Amputation; the Peroneal Artery the Source of the Bleeding; the Occluding Plug of Coagulum and Fibrine had softened and yielded to the Impulse of the Blood. — 7th. Secondary Hemorrhage often occurs in Connection with Traumatic Aneurism. — An Illustrative Case. — Gunshot Wound of Axillary Artery; Diffused Traumatic Aneurism; Secondary Hemorrhage on Tenth Day; Deligation of the Subclavian; Hemorrhage recurred three Days afterwards; Consecutive Gangrene; Death; Autopsy. — 8th. Secondary Hemorrhage is not unfrequently produced by Imperfect Closure of Breaches in Wounded Arteries. At first the Bleeding is arrested spontaneously, but afterwards the Adhesive Process fails to close the Traumatic Orifice permanently, either because the Wounded Vessel is imprisoned in some Bony Canal, which holds it open at the Place of Injury, or because it is situated in some Part whose Mobility is so great as to

obstruct the Healing Process in the Arterial Wound. — Two Illustrative Cases related. — 9th. Secondary Hemorrhage not unfrequently occurs from the Distal Orifice of Wounded Arteries. — Two Cases referred to. — 10th. Scurvy promotes the Occurrence of Secondary Hemorrhage. — An Illustrative Case contributed by Dr. W. Clendenin. — Scorbutus; Gunshot Wound, involving Brachial Artery; Secondary Hemorrhage on the Sixth Day arrested by Ligation of Artery at Place of Injury, both Proximal and Distal; Reference also made to Thirteen Additional Cases of Scorbutic Hemorrhage. — Dr. Clendenin's Contribution continued. — His Experience concerning Scorbutic Hemorrhage from the Radial and Ulnar Arteries. — Also from the Posterior Tibial Artery. — Dr. John Wilson's Remarks on the Causes of Secondary Hemorrhage. — Depravation of the Blood the Prolific Source of this Form of Bleeding. — 11th. Secondary Hemorrhage is sometimes induced by the Injuries attendant on the Transportation of the Wounded. — A Case related by Guthrie. — 12th. The Occurrence of Secondary Hemorrhage is promoted by the Operation of Moral Causes of a Depressing Nature. — Some Interesting Notes on this Subject. — On the Influence of Atheroma and Ossification of Arteries in producing Secondary Hemorrhage. — Mr. Paget's Remarks on this Subject. — When Secondary Bleeding occurs from an Artery wounded or tied in the Continuity of a Limb, the Distal Orifice is more frequently the Source of the Hemorrhage than the Proximal. — Secondary Hemorrhage, in whatever Way produced, generally implies some Defect in the Healing Process. — On the Prophylactic Treatment of Secondary Hemorrhage.

Definition of the term.

By the term secondary hemorrhage we designate all bleedings from wounded arteries which occur subsequent to the establishment of suppuration, that is, subsequent to the fifth or sixth day after the infliction of the wound, and all losses of blood occasioned by the spontaneous rupture or opening of the sac in cases of traumatic aneurism. This accident belongs to the secondary period, strictly so called, and is apparently connected with the process of suppuration, especially the unhealthy forms thereof. It may occur during any part of the secondary period; but, according to the statement of surgical writers, it is more liable to happen between the *fifth* and *twentieth* days, and especially so about the *fourteenth* day.

Connected with process of suppuration.

Between the 15th and 20th days.

But this statement does not exactly accord with the results of the writer's observations and researches. For example, in the pages of this essay, sixty-five cases of secondary hemorrhage, all of which occurred in the late war in this country, are either related more or less fully, or distinctly referred to. Of these 65 cases of secondary hemorrhage, 5 occurred on the *fifth* day, 7 on the *sixth*, 8 on the *seventh*, 3 on the *eighth*, 2 on the *ninth*, 3 on the *tenth*, 1 on the *eleventh*, 3 on the *twelfth*, 5 on the *thirteenth*, 5 on the *fourteenth*, 2 on the *fifteenth*, 3 on the *sixteenth*, 1 on the *seventeenth*, 2 on the *eighteenth*, 2 on the *nineteenth*, 1 on the *twentieth*, 2 on the *twenty-second*, 3 on the *twenty-third*, 1 on the *twenty-seventh*, 1 on the *twenty-eighth*, 1 on the *thirty-first*, 1 on the *forty-first*, 1 on the *forty-second*, 1 on the *sixty-ninth*, and 1 on the *eighty-fifth* day. Total, 65 cases.

Summary of 65 cases.

It should be stated, however, that of the 20 cases, in aggregate,

of secondary hemorrhage, which occurred on the *fifth*, *sixth*, and *seventh* days, 11, or somewhat more than one half of them, had a *scorbutic* character or origin. This fact should be borne in mind while using the foregoing table for purposes of comparison, because it appears that secondary hemorrhages occurring in scorbutic subjects are much more liable to happen on the days above mentioned, than at a later period.

In scorbutic subjects on 5th, 6th, and 7th days.

Causes of Secondary Hemorrhage. — This form of after-bleeding, when we come to investigate its clinical history, is found to be the product or result of a considerable variety of proximate physical agencies. An analysis of the cases narrated in these pages shows, *in the first place*, that secondary hemorrhage is not unfrequently produced by a *contused wound of the coats of an artery.* In such cases the bleeding is restrained until the bruised portion of the arterial tunics, which becomes a slough, is separated from the sound portion, when the blood immediately begins to flow. For example, we have already seen, in the history of Case No. II., that the posterior tibial artery was contused by a bullet, and, the slough separating, secondary hemorrhage occurred on the eighth day. We have also seen in Case No. III. secondary bleeding take place on the sixteenth day, from a posterior tibial artery whose walls had been bruised by a gunshot projectile.

Variety of causes.

By contused wound of artery.

And in the following case, which was contributed by Dr. Benjamin Woodward, secondary hemorrhage from the internal carotid artery occurred on the seventh day, from the separation of a slough that was occasioned, in all probability, by a contused wound of its walls.

Illustrative case.

CASE LVII. *Gunshot Wound of Face and Neck, with Compound Comminuted Fracture of Lower Jaw on Right Side; very Profuse Secondary Hemorrhage on Seventh Day, from Internal Carotid Artery, which had sloughed; Convulsions; Ligation of Common Carotid Artery; Bleeding arrested permanently; Death on Seventh Day afterwards, from Meningitis and Softening of the Brain; Autopsy;* contributed by Dr. Benjamin Woodward, late Surg. 22d Ind. Vols. — Percival B. Messenger, Sergeant Co. A, 111th Penn. Vols., wounded at Lookout Mountain, Nov. 25, 1863. Admitted to General Hospital, Tullahoma, Tenn., on the 27th of Nov., 1863, for gunshot. Comminuted fracture of the lower jaw on right side. Ball passed in at right angle of the mouth, and ranging back, shattering the jaw, made its exit through the neck, by the side of the second cervical vertebra. Great swelling of the parts; so much so that no efforts could be made to remove the broken bones. Water dressings were applied, and an opiate administered.

December 2. — Wound discharging freely; no hemorrhage; at noon he fed himself with soup. About 1 P. M. I was called to him: "he was bleeding;" found that the internal carotid artery on right side had sloughed; four quarts of blood, by measure, were collected in a tin basin. Convulsions came on. I pressed lint soaked with liquor ferri persulph. into the wound by the mouth, and also through the back of the neck, and, holding it there, directed my assistant surgeon, Dr. Pierce, of the 150th New York Vols., to cut down and ligate the trunk of the common carotid artery. The convulsions were so severe that the operation was extremely difficult, but it succeeded. The blood ceased to flow, but the lint was left *in situ*. Pulse at wrist imperceptible; breathing, gasping. He was wrapped in hot blankets and left on the operating table for four hours. Teaspoonful doses of extract of beef and brandy, in equal parts, were given, as soon as he could swallow. 9 P. M., pulse perceptible, but extremely weak; removed him to his bed. 11 P. M., pulse 160; extreme "vigilance;" gave him one quarter grain of morphia every four hours till he slept.

December 3. — 7 A. M., has slept a little. Pulse 140. 10 A. M., removed the lint, and cleared the mouth; no return of hemorrhage. Bowels moved, and he has urinated. 8 P. M., has slept four hours; gave wine ℥ij and extract beef ℥ij every two hours.

December 4. — 8 A. M., has slept well; pulse 120, growing fuller. No hemorrhage; wound in neck suppurating well; sits raised in bed; takes nourishment freely, but is extremely weak; no cerebral symptoms; bowels moved well. 2 P. M., pulse 110; he has dictated a letter to his wife.

December 5. — 8 P. M., doing well; pulse 98 and growing full; head feels clear; bowels have moved to-day; he wants oysters, which are given him freely.

December 8. — There has been no change till last night. His pulse now at 10 A. M., is 120, and very soft. Evidence of cerebral symptoms show themselves by hebetude and listlessness. Breathing very feeble. There is slight but perceptible divergence of the right eye. His appetite, which has been good, is failing. I think we have softening of the brain. 5 P. M., same day; great hebetude; can hardly be roused; pulse 120, very soft and feeble. 8 P. M., coma and complete paralysis of the left side.

December 9. — He died at 1 A. M.

Autopsy. — *Brain.* — Right hemisphere seemed to be more pallid than the left one. Every portion covered with lymph, and there is some serum under the arachnoid. Dissecting out the carotid artery, from innominata to base of skull, we found that *the internal carotid had sloughed for a space half an inch in length*, and embracing about half the circumference of the vessel. At the place of ligation a firm clot was found extending half an inch below, and one and three fourths inches above

the ligature. The internal carotid artery was completely occluded by a firm fibrinous clot as far as the entrance of the skull above, and half an inch below the slough, so that in no event could hemorrhage have again taken place. The jaw was a mass of putrilage, and pus had followed down the sheath of the artery, bathing all the parts for a full inch below ligation and dissecting out the artery and nerve.

The artery was preserved as a wet specimen, and sent with the history of the case and the autopsy to the Surgeon-general for the Army Medical Museum.

Comments. — An important feature of the foregoing case, in a practical point of view, was that the plugging up of the wound and the employment of local pressure *retarded* the flow of blood until a ligature could be applied to the common carotid artery, although the hemorrhage was so profuse that four quarts of blood, by measure, were collected in a vessel, and convulsive movements were induced by the loss of blood.

Important features of case.

Another important feature of the case was that the bleeding, which was arrested by ligation of the common carotid artery, did not recur; and at the autopsy it was found that the internal carotid at the place of injury, as well as the common carotid artery at the place of ligation, was undergoing the process of obliteration. The patient died, not of hemorrhage, but of meningitis and softening of the brain.

In the *second* place, secondary hemorrhage is sometimes produced by the separation of the slough, which not unfrequently surrounds the track made by gunshot projectiles, in the soft parts of the body; and the following instance of secondary bleeding from a flesh wound of the thigh, inflicted by a minie ball, appears to belong to that category.

By separation of slough in the track.

Case LVIII. — *Secondary Hemorrhage following Gunshot Wound of Thigh (Flesh) on Eleventh Day; Ligation of Femoral Artery on the Plan of Hunter; Consecutive Gangrene and Death on the Eighteenth Day after the Wound was inflicted;* reported by Dr. Edward Batwell, Surgeon in charge of Hospital, Second Division, Fourteenth Army Corps. — Sergeant G., 16th Ill. Vet. Vol. Infantry, received a minie ball through the left thigh, about three and a half inches above the knee-joint, grazing the femur, but not injuring it. Everything progressed favorably towards convalescence, and on the tenth day the slough separated. On the eleventh I was hastily summoned by the surgeon in charge of the ward, who reported that considerable hemorrhage had taken place. On examination I found he had lost about eight or ten ounces of blood, but that it had now entirely ceased. A tourniquet was applied loosely over

the artery, and directions given to an intelligent nurse to tighten it on the least indication of bleeding; toward evening some oozing took place, but the application of persulphate of iron quickly controlled it. On the afternoon of the twelfth day, another gush of blood took place, in which about five or six ounces of blood were lost. The tourniquet was applied so as to control the bleeding, but not to arrest the circulation entirely. Next afternoon another gush of about four ounces of blood indicated that the operation of ligating the femoral artery could no longer be delayed. Accordingly, I cut down upon and tied that vessel in the middle of its course, enveloping the limb in flannel, and using every available means to keep up the temperature of the leg. He seemed very comfortable for about thirty-six hours, when, notwithstanding all the efforts used, the temperature fell, and ere twelve hours it became evident that mortification must ensue. During this time he was using brandy-punch; beef-tea, and everything that would tend to nourish and support his system, was freely administered; but he gradually sunk into a comatose condition, and died on the eighteenth day after the reception of the injury. Some may think that the operation was employed at too late a period; but the loss of twenty ounces of blood was not sufficient reason to interfere, as the bleeding was not constant, and the nervous condition of the patient made it advisable to defer any serious operation. Secondary amputation would not have produced any good effect, as the mortification spread too rapidly, even beyond the point of operation; besides, secondary amputation is "played out" in this army. [1]

It is probable, however, that in the cases belonging to this category the vessel or vessels from which the after-bleeding springs have sustained some injury directly from the projectile, and that the healing process has been too feeble to repair the bruise or breach in the walls of the wounded vessels.

In the *third* place, secondary hemorrhage is not unfrequently developed in consequence of the extension of the slough- By extension of the slough.
ing process, *in unhealthy constitutions*, from the tissues situated exterior to an artery, to the coats of the artery itself when they were not primarily injured. The bleeding in such instances occurs on the separation or the breaking down of the slough. The next three cases, wherein secondary hemorrhage occurred Three illustrative cases.
from the posterior tibial, subclavian, and brachial arteries respectively, are here introduced in confirmation of the views expressed in this paragraph. We may also state that this form of after-bleeding is not unfrequently met with in parts that are involved in, and undergoing destruction by hospital gangrene, and

[1] Vide *Med. and Surg. Reporter*, January 28, 1865, pp. 254, 255.

some of the most striking instances of it ever witnessed by the surgeon, have occurred during the progress of that affection. In the cases belonging to this category the bleeding occurs from a part of the vessel where the walls have not been primarily injured by the projectile. The solution of continuity is specially due to a morbid process of a destructive character. This process is much more rapid in its progress than simple ulceration. It is usually called *sloughing ulceration* in the less severe, and *sloughing phagedæna* in the worst instances.

Sloughing ulceration and sloughing phagedæna.

Case LIX. — *Secondary Hemorrhage from Posterior Tibial Artery following Gunshot Wound with Fracture of Leg, in Upper Third, on Thirteenth Day; Deligation of Vessel at Bleeding Point, both above and below; in Three Days the Hemorrhage recurred profusely; tied the Femoral Artery under the Sartorius Muscle; on the Following Day the Hemorrhage again returned; amputated the Limb; Death;* case reported by Dr. James M. Holloway. — N. Parker, Corporal 51st Regt., Co. "B": occupation farmer; aged forty years; general health good; wounded at Drury's Bluff, May 16, 1864. Gunshot wound of left leg, ball entering to the inner side of tubercle of tibia, and, passing through that bone, made its exit through calf at a point two and a half inches below the wound of entrance. He was in the act of stepping forward on the limb. I saw the patient for the first time on May 23d. He had experienced no untoward symptom since receipt of injury; wound of exit nearly closed by granulation; that of entrance not discharging, and showing no disposition to fill up. Treatment, cold water dressings and rest in recumbent posture.

May 28. — *Slight hemorrhage from wound of entrance* last night; patient states that the blood was black, inducing the belief that it came from cancellous structure of the bone.

May 20. — *Bled again more profusely last night; decidedly arterial; again at daylight this morning;* and again at 9 A. M., after a severe rigor. *Diagnosis:* Secondary hemorrhage from the posterior tibial in its upper third, occuring on the thirteenth day after injury. *The artery was then ligated above and below the bleeding point.* The lateral operation, as described by Druitt, was employed; there was much delay in securing the vessel, occasioned by its great depth and the *sloughing condition of the surrounding tissues;* the incisions were necessarily extensive; shock from operation great; wound of exit in tibia stellated, and spicula of bone protruded. Cleansed the wound, approximated its edges, and applied a roller bandage.

May 30. — Passed a sleepless night; reacting slowly; suffers from strangury, which was relieved by warm stupes and enemata; limb below knee warmer than before ligature; temperature still less than normal; applied sand-bags; administered three grains of quinia every two hours, to ward off chill; nutritious diet and stimulants.

May 31. — Experienced another chill at half past eight A. M.; reacted without much fever; pulse depressed, but regular; complains of severe pain in limb; discharge from wound thin, dark, and very offensive; dressed with turpentine; prescribed quinia in sedative doses; stimulants and anodynes.

June 1. — Seized with another chill at 11 A. M.; *hemorrhage recurred, very profuse and exhausting; supposed to be from extension of slough. At* 12 M. *the femoral artery was ligated as it passes under the sartorius muscle;* limb very much reduced in temperature compared with the other; cleansed wound and applied flannel roller from toes upward, and dressed with Labarraque's solution; suffers severe pain throughout the entire limb. Continue constitutional treatment.

June 2. — Half past five A. M. Slept at intervals during night; discharge from wound thin, unhealthy pus, mixed with decomposed blood; very offensive; lips of wound sloughing. 12 M. *Hemorrhage recurred. At earnest request of patient, the thigh was amputated in its lower third.* The main arterial trunk required ligature. He failed to react from the shock of operation, and died the same evening at 4 o'clock. He retained his intelligence until about one hour before death, and after the last hemorrhage insisted upon the amputation, otherwise I should have declined doing it. *Examination of the amputated member showed an extensive slough, involving the artery above and below the ligatures, and the surrounding tissues.*[1]

Comments. — In this case of secondary hemorrhage from the posterior tibial artery, the procedure advocated by Guthrie was adopted in the first instance, and the vessel was tied both above and below the bleeding orifice. It failed to permanently arrest the bleeding because the sloughing process extended to the artery both above and below the points where the ligatures were applied. With regard to the secondary hemorrhage itself, for the suppression of which the ligatures were applied to the posterior tibial artery, it should be stated that it was probably occasioned at the outset by the extension of the sloughing process from the surrounding tissues to the walls of the vessel itself. Then on the separation or detachment of the dead and disorganized portion of the coats of the artery a gush of blood usually takes place, and secondary hemorrhage is fully inaugurated. In some cases, however, the after-bleeding commences with the escape of only a small quantity of blood, as it did in the instance now under consideration. But this premonitory hemorrhage is almost always followed, in a short time, by a profuse flow of blood, which may destroy the patient's life on the spot, or, as more frequently happens, it may recur again and again,

[1] Vide *American Journal Medical Sciences*, Oct. 1865, p. 344.

until the sufferer dies, exhausted from the loss of blood, unless, perchance, efficient surgical assistance is obtained.

CASE LX. *Secondary Hemorrhage from Subclavian Artery, following Gunshot Wound, and occurring Twenty-two Days after its Infliction; Deligation of Proximal End of Bleeding Vessel; Hemorrhage recurred and Patient died Twelve Days afterwards; Autopsy; Subclavian and First Part of Axillary Arteries sloughing;* case reported by Dr. James M. Holloway. (Special notes of this case were recorded by Dr. E. M. Seabrook, who performed the operation, and continued in charge of patient afterwards. I can only give the prominent facts.) — E. F., soldier; aged about twenty-five years; general health good; wounded June 2d, 1864. Gunshot wound through left shoulder, ball entering in front and traversing the subclavian triangle. Profuse hemorrhage suddenly occurred on the evening of the 24th of June, twenty-two days after receipt of injury. The wounds had almost closed externally. *Diagnosis:* Indeterminate hemorrhage from the subclavian artery. The anterior wound was enlarged, and a ligature thrown around the artery above the bleeding point; operation performed by candle-light; the sense of touch was of great assistance in finding and securing the vessel; shock following the operation, which was tedious and attended with considerable loss of blood, very great. Another slight hemorrhage occurred a few days later, which proceeded from the transversalis colli; it was tied.

July 6. — Patient died to-day after another hemorrhage. *Autopsy* (made by myself): the surrounding tissues were completely disorganized; the first rib was fractured; *the subclavian artery had sloughed throughout its entire extent, and the first part of the axillary was invaded.*

The first hemorrhage was evidently the result of ulceration of the coats of the vessel, for the parts were not in a sloughing condition at the time the ligature was applied. The operation was followed by great depression of the vital energies, a natural consequence of the loss of blood and the protracted use of chloroform during the delay in finding and securing the bleeding vessel.[1]

The following case was contributed by Geo. M. Wilson, Acting Assistant Surgeon, Field Hospital of Fifteenth Army Corps: —

CASE LXI. *Gunshot Wound of the Elbow; Secondary Hemorrhage on Sixth Day; Amputation; Recovery.* — Jesse L. Adkins, Corporal Co. H, 6th Ind. Vols., wounded at the battle of Kenesaw Mt., Ga., June 27th, 1864. Ball entered the anterior aspect of the right fore-arm about the elbow, emerged posteriorly two inches below the joint. Admitted to the hospital June 30. Seemed much depressed. Arm swollen, and dressed with flaxseed poultice. Cold dressing and bandage from wrist to axilla were applied.

July 2. — Swelling diminished; patient much better.

[1] Vide *American Journal Medical Sciences*, Oct. 1865, p. 345.

July 3. — *Hemorrhage took place from the brachial artery* (patient lying still at the time), causing loss of considerable blood. Surgeon Goslin, 48th Ill., immediately amputated the arm — circular method — taking off four inches of the lower part of the humerus, of which bone the outer condyle was found badly shattered. The olecranon also was broken off. *The artery had sloughed for some distance*, and the condition of the arm would not permit of resection.

Patient left hospital July 27th, 1864 — doing well — stump almost entirely healed.

In the *fourth* place, secondary hemorrhage occurs when the coats of arteries are perforated, and their calibre penetrated, by simple ulcerative inflammation. The ulcerative process may be excited in the walls of arteries by fragments of bone pressing against them, while the general health of the subject remains unimpaired, as happened in the two cases which are narrated next; or it may occur spontaneously, which happens not unfrequently in certain depraved conditions of the organism; for example, those induced by typhoid diseases, by the purulent infection, by scrofulosis, and by excessive loss of blood.

By simple ulceration.

The next case is very interesting and instructive. In it ulceration of the coats of an important artery was produced by pressure from a fragment of broken bone. It occurred in the author's practice.

Case LXII. *Gunshot Wound of Right Ankle-joint involving Tibia and Astragalus; Profuse Secondary Hemorrhage arterial in Character on the Eighty-fifth Day, for which Secondary Amputation was performed; Dissection of Amputated Member showed that a Spicula of Bone had caused Ulceration and Sloughing of the Posterior Tibial Artery through Pressure; Death on the Twentieth Day after the Operation, from Exhaustion.* — Private Jacob Rudolph, Co. E, 4th Mich. Vols., aged 24, was wounded in the right ankle, by a rifle-ball, in the battle at Cold Harbor, June 3, 1864, and was admitted to Stanton U. S. Army General Hospital, June 12. It was found that the ball had entered in front of the external malleolus, and made its exit below the internal malleolus, fracturing the lower end of the tibia and the astragalus. He did tolerably well till the 27th of August, when a profuse flow of arterial blood unexpectedly occurred from the wound, which reduced him very much. The ankle-joint being wounded, the extent of injury of the bones connected with that articulation being uncertain, his general condition being very low, and the soft parts being much swelled and inflamed, it was thought that amputation afforded him the best chance for his life. That operation was performed without delay by the author, at

the place of election in the leg, by the flap method (short anterior and long posterior flap). The limb was somewhat œdematous at the place of operation. The anæsthetic was sulphuric ether. He was put upon a strongly supporting treatment, consisting in the administration of nutrients, stimulants, and tonics p. r. n.; but they did not get him over the effects of the hemorrhage. He gradually failed, and died on the 16th of September of exhaustion, twenty days after the hemorrhage.

On dissecting the amputated limb it was found that *the bleeding occurred from the posterior tibial artery; that the pressure of a spicula of bone had caused ulceration and sloughing of a portion of it*, and that the articular surfaces of the tibia and astragalus were extensively comminuted. *The piece of bone had been driven by the bullet against the artery.*

The following case, strictly speaking, does not belong to the category of traumatic hemorrhage, but its history is, nevertheless, very interesting, and presents several points of resemblance to that of the case last narrated.

Case LXIII. *Death from Hemorrhage caused by a Sharp Sequestrum which had penetrated the Popliteal Artery, by causing Ulceration of its Coats.* — Dr. William Hunt reported the following case to the College of Physicians of Philadelphia.

J. P., aged 19, was admitted to the Pennsylvania Hospital November 9th, 1864, after an alarming hemorrhage, which came through sinuses communicating with dead bone in the popliteal space. His countenance was pale and anxious; pulse frequent, quick, and small; tongue glazed, dry, and aphthous; respiration hurried; bowels costive, and abdomen meteoric. He had slight delirium at night, and constant jactitation. Old sinuses and cicatrices pointed to necrosis, the origin of which was uncertain, but was supposed to have been first caused by a fall on the ice in the winter of 1861–2. As there was no bleeding at the time of admission, the full extent of the necrosis was not ascertained, as a thorough exploration would have endangered a return of the hemorrhage. Perfect rest, nourishing food, persulphate of iron, and chlorate of potash were prescribed. A bandage was applied to the limb, which had become œdematous, and it was also elevated. At this time slight pulsation could be detected in the tibial arteries. On consultation it was determined that if the hemorrhage returned, to etherize the patient, open the wound, and amputate or ligate, according to the result of the exploration. The patient's comfort was greatly improved, but his general condition cannot be said to have responded to the treatment. The condition of hydræmia, into which he was thrown from the great loss of blood before entering the hospital, gave very poor hopes of recovery.

A drop of his blood on a glass slide spread over a much greater space, and coagulated in much wider meshes than healthy blood.

Under the microscope there was a marked diminution of red, and an increase of white corpuscles.

On Sunday, November 20th, an alarming hemorrhage commenced, but it was promptly checked by compresses and the tourniquet. From this time pulsation in the tibial vessels entirely ceased. The patient was so weak as to forbid operation when the attending surgeon arrived.

On Tuesday following about three ounces of blood were lost, after which the patient gradually sank, and died on Wednesday night. The whole amount of blood lost while in the hospital did not exceed six or eight fluid ounces.

Autopsy. — No examination of the viscera permitted. The connective tissue around the wound was infiltrated with serum and lymph. The muscular interspaces were filled with decomposing blood and broken-down tissues, including those of the nerves and blood-vessels, which were involved in the general pulpy mass. An internal sinus communicated directly with the femur, which was partly denuded; and on the posterior surface of said bone there was a large cloaca with thickened and rounded edges; from this *there projected inwards and downwards a very sharp, movable sequestrum, which was three inches in length, and had compressed and finally penetrated or cut across the main artery directly after its passage through the great adductor tendon.* The medullary cavity of the femur was obliterated for the space of two inches above the seat of the disease.[1]

The foregoing case presents a strong similarity, in its leading features, to some instances of movable sequestra at the lower part of the femur, which are noticed in the chapter upon *necrosis*, that may be found in another part of this work.[2]

In the next two cases the coats of the popliteal and subclavian arteries were respectively pierced and destroyed by the ulcerative process to such extent as to cause very profuse secondary hemorrhage. In both of them the occurrence of the ulceration in the arterial tunics appear to have been occasioned by a depraved condition of the general health.

CASE LXIV. *Gunshot Wound of Right Leg (Calf) in Upper Third; Secondary Hemorrhage on Forty-first Day; Ligation of Femoral Artery; Death Four Days afterwards from Pyæmia; Autopsy; Bleeding occurred from Lower Part of Popliteal Artery, which had been extensively opened by Ulceration.* — Sergeant James Ferguson, Co. G, 142d Penn. Vols., a young man of good constitution, was admitted to Stanton U. S. Army

[1] Vide *American Journal Medical Sciences*, July, 1865, pp. 94, 95.

[2] Vide Chapter on Necrosis in Section Second.

General Hospital, December 29th, 1862, sixteen days after the first battle of Fredericksburg, on account of a gunshot wound of the right leg, received in that battle, December 13th.

The bullet passed through the calf of said leg, in its upper third, behind the tibia and fibula, in a downward and outward direction. The wound did well until the middle of January, when the granulations assumed an unhealthy appearance, and the discharge became thin and serous. He also exhibited typhoid symptoms, having a hot skin, a frequent pulse, a dry, red tongue, watchfulness, and no appetite. In this way he went on from January 15th until Friday morning, January 23d, when hemorrhage unexpectedly occurred from the external orifice behind fibula. The officer of the day, Dr. Osborne, readily controlled the bleeding by the application of pressure with a roller bandage and ice. Dr. Osborne thought the patient lost in all about ten ounces of blood. Through that day and night the loss of blood by oozing was very little. On Saturday morning, January 24th, the bleeding recurred, from the internal orifice behind the tibia this time. Dr. Mursick, his attending surgeon, was in the ward when the bleeding commenced. He readily controlled the bleeding by the application of persulphate of iron, lint, ice, and bandaging. He lost this time from four to six ounces (not more than last figure), of blood. In the mean time the typhoid symptoms became more marked; he complained of great tenderness throughout the leg and thigh; the inguinal glands were somewhat swollen and tender; and there was dusky redness with soreness in the track of the long saphenous vein. His skin was now pale yellow, and he presented other symptoms of pyæmia.

On Sunday morning a slight bleeding occurred from the internal wound, which was readily controlled by pressure and ice; there was a marked increase of swelling of the leg noticed this morning, and infiltration thereof with blood was suspected. The swelling was extending from the leg to the thigh, especially over the external and internal condyles, and the popliteal space also was already filled up with the swelling. He was very pale and sallow, and expressed a great deal of anxiety; pulse 120, quick and weak.

On Friday we thought the hemorrhage came from the peroneal artery, on Saturday from the posterior tibial; at all events, we were uncertain on Sunday morning with regard to the source of the bleeding. The case now presented an exceedingly unpromising appearance, on account of the debility from a loss of about eighteen ounces of blood, in all, not more than that, supperadded to typhoid disease or condition.

It was decided to tie the femoral artery at the apex of Scarpa's space, as affording the best chance of prolonging life. That operation was accordingly performed by the author, on the afternoon of that day, Sunday, January 25th, 1863, forty-three days after he had been wounded. The patient was manifestly pyæmic, and we scarcely hoped for his recovery on that account.

Monday morning, January 26. — Patient appeared brighter, pulse 130; tongue more moist; leg getting warm, down to the ankle; plugs removed from wounds, and some dark, offensive blood flowed away. Six P. M., foot cold; leg cooler, blackness extending across the leg in track of wound; tongue dry; has had a slight chill, and he is somewhat delirious; pulse 130, and weak.

Tuesday, January 27. — Morning. Patient looks better than last evening; pulse 132, and stronger; leg warmer and blacker; foot pale and swelled (serous infiltration); serous infiltration and discoloration extends up the thigh.

Wednesday, January 28. — Patient presents a pale, yellow hue; blackness of limb deepening and extending; has reached the lower end of the incision for tying femoral artery; odor gangrenous.

Thursday, January 29. — Patient sinking; and he died in the evening, four days subsequent to the deligation of the femoral artery.

The *autopsy* showed that the bleeding came, not from the posterior tibial, nor the peroneal artery, as had been supposed, but from the lower part of the popliteal artery, which had been opened to large extent by ulceration. It was also found that the ball had grazed the hind part of both the tibia and fibula in its track, and there were some loose splinters, small in size, in relation with the tibia and fibula.

A piece of the femoral artery four inches long was taken out, which embraced the seat of the ligation. *On the proximal side of the ligature, the clot was firm, closely attached to the walls of the artery, and about three quarters of an inch in length, with its apex pointing upwards toward the heart. On the distal side of the ligature, there was also a small, firm clot, adherent to the walls of the artery; but this clot was much smaller than the proximal one. Both of these coagula were conical in shape, and attached to the lining membrane of the artery at and in the neighborhood of their bases only.*

The specimen was sent to the Army Medical Museum.

Case LXV. *Gunshot Wound of Subclavian Artery; Secondary Hemorrhage Twenty-two Days afterwards from Ulceration of its Walls; Death;* case reported by Asa Alonzo Smith, M. D., Acting Assistant Surgeon U. S. Army. — Private Levi Reylea, Co. D, 16th Penn. Cav., aged 25, wounded August 16th, 1864, in action near Malvern Hill, Va., was admitted to the Satterlee U. S. Army General Hospital, August 20.

On admission to hospital his general health was good. His appearance, however, showed that he had recently lost a large quantity of blood. In the right clavicular region, about one inch from the sternum, was the hole made by the projectile, through which the finger passed under the clavicle, backwards and outwards, over the upper side of the first rib. The clavicle was broken. There was no orifice of exit, and hence it was supposed that the bullet lodged. A great many very small

pieces of bone were felt firmly fixed in the tissues around the track of the ball. No pulsation could be felt in the arteries of the right arm. Auscultation and percussion showed the thoracic cavity to be untouched. An expectant plan of treatment was adopted.

September 7, 7½ P. M. — Profuse hemorrhage from the wound occurred, and some fifteen or twenty ounces of blood were lost in a few minutes. It was arrested by the nurse, through pressure applied with a narrow roller bandage, as had been directed. A consultation was called, and decided to continue the pressure in the wound until the next day.

September 8, 11½ A. M. — A consultation was again held, and it was decided to place a ligature at once around the subclavian artery between the wound and the heart, and after that to act as circumstances might indicate. The usual incisions were made for this purpose, but no artery could be found in the place usually occupied by the subclavian. On sliding the finger down the scalenus muscle against the first rib, it perceived an organ irregularly rounded, but not hollow nor pulsating, and attached quite firmly to the surrounding parts. With difficulty a thread was passed round this organ; it was left for a few moments, and then removed without having been tied. After long hesitation it was determined to ligate a vessel, probably the superior scapular artery, beating in the upper part of the incision, and running in such a direction that it might open into the wound. This was the only pulsating vessel anywhere to be felt, on exploring both the wound and the incisions with the fingers. There was no hemorrhage during the operation. One small vessel, that spouted in the subcutaneous cellular tissue after the first incision, was tied immediately. The patient was kept more or less fully under the influence of chloroform, mixed with ether (one part of the former to three of the latter, by measure), while the operation lasted.

An hour after the operation there was considerable reaction; the general expression was good; the body much warmer; the pulse ninety-eight. In the afternoon the pulse was ninety-five, with more volume and strength.

At quarter past five P. M., the hemorrhage recurred, and before proper compression could be exercised, a large amount of blood was lost. After this the pulse was scarcely perceptible; the face was blanched and covered with heavy drops of sweat; the extremities cold; thirst intense; and he was very restless. He continued in this condition, his mind remaining clear, until the next morning at five o'clock, when, without any further loss of blood, he began to sink rapidly, and died at eight o'clock.

At the *autopsy*, the clavicle was found splintered; the first rib slightly touched just outside of its tubercle; and the scapula perforated one inch below its spine. *The subclavian artery had been lacerated by the ball where it crosses the first rib; it was here entirely plugged up for a space*

of two inches, and looked like a sloughing mass, having a number of very small pieces of bone scattered through it. The hemorrhage had come from the vessel within the scaleni muscles, where an opening through its coats, the product of ulceration, was found. The subclavian vein had been torn away by the ball. The cavity of the chest and its contents were perfectly healthy.[1]

The foregoing case is exceedingly interesting and instructive. It presents us with an example of gunshot laceration of the subclavian artery and vein, the primary bleeding from which appears to have ceased spontaneously. The vascular lesion, notwithstanding its importance and extent, was not followed by traumatic gangrene. It was reserved for secondary hemorrhage to destroy this patient.

In the *fifth* place, secondary hemorrhage is not unfrequently produced by the non-union or non-obliteration of arteries when they have been secured by ligature. In such cases, when the ligature separates and comes away, the blood flows out from the unclosed and patulous mouth of the vessel. The case of James N. Saxon, the history of which is related in the chapter on *osteo-myelitis* (No. XXVII.), furnishes a very striking illustration of this variety of secondary bleeding. He sustained secondary amputation of the thigh for gunshot injury on the 18th day of November. On the morning of December 3d, the ligature separated from the femoral artery, and hemorrhage, in a great stream, immediately supervened. He lost so much blood before its flow could be stopped, that he died *eight* hours afterwards. The *autopsy* showed that the mouth of the femoral artery was patulous and undiminished in size, and that no attempt to obliterate it had been made.

By non-union of arteries when they have been tied.

Case of Saxon.

In the *sixth* place, secondary hemorrhage is sometimes produced by the liquefaction and breaking down of the adhesions which have been formed at the mouth of a wounded artery, and by which it has been closed. When this retrograde metamorphosis of the fibrinous material by which the orifices in wounded vessels are, in general, permanently sealed up, takes place, it denotes a deteriorating condition of the general health of the patient. Such a liquefaction of the adhesions formed at the proximal orifice of the severed axillary artery, probably occurred in the case of Capt. Jordan (No. XXXVII.), and allowed the secondary hemorrhage to occur.

By liquefaction of the adhesive material.

In the following case, which occurred in the author's practice,

[1] Vide *American Journal Medical Sciences*, Oct. 1864, pp. 550–552.

secondary after-bleeding appears to have been produced in the way just mentioned.

CASE LXVI. *Secondary Hemorrhage from a Gunshot Wound of Leg, severing the Peroneal Artery, with Fracture of the Fibula, occurring on the Fourteenth Day; Amputation; Death from Pyæmia Eleven Days afterwards; the Peroneal Artery the Source of the Bleeding; the Occluding Plug of Coagulum and Fibrine had softened and given Way before the Blood-pressure.* — Private George Hang, Co. G, 2d U. S. Artillery, aged 27 years, was admitted to the Stanton U. S. Army General Hospital, June 4th, 1864, from the field, on account of a gunshot wound of his right leg, which was complicated with a badly comminuted fracture of the fibula. The injury was inflicted at Cold Harbor, Va., May 31st.

On the morning of the 14th of June, secondary hemorrhage, arterial in character, occurred from the wound, and he lost about ten ounces of blood. At the same time the leg was greatly swelled and inflamed all the way up to the knee. His pulse was small and frequent, and he exhibited other symptoms indicating the approach of irritative fever. It was therefore thought best to amputate the member, which was accordingly done, by Acting Assistant Surgeon Charles H. Osborne, at the lower third of the thigh by the circular method. Sulphuric ether was employed as the anæsthetic.

On examining the amputated member it was found that *the muscles of the leg were extensively infiltrated with purulent matter, that the peroneal artery was severed, and that the hemorrhage had proceeded from it, from liquefaction of the occluding clot, and the fibrinous exudation at the mouth of the vessel.*

Subsequently he got pyæmia, and died of that disease, eleven days after the operation.

It seems that the deteriorating condition of this man's general health, and the purulent infiltration of the tissues of his leg, together, sufficed to produce a molecular disintegration of the fibrinous substance by which the mouth of the severed peroneal artery had been closed, and thus occasioned the occurrence of hemorrhage. It is a significant circumstance that he died of pyæmia only eleven days after the operation.

Often occurs in connection with traumatic aneurism.

In the *seventh* place, secondary hemorrhage is often produced by the rupture, or the spontaneous opening of the sacs of traumatic aneurisms. In the preceding pages of this essay we have already related three cases in which that accident occurred, and was attended with the loss of much blood.[1]

[1] Vide Cases XXXIX., XLIII., and XLIV.

In the following instance of diffused traumatic aneurism, which was produced by a gunshot wound of the axillary artery, a spontaneous opening of the aneurismal sac was formed, on the tenth day after injury was inflicted, at the anterior orifice of the gunshot wound, and the patient lost a pint of blood before the hemorrhage could be restrained by pressure. The subclavian artery was then tied; but, three days afterwards, secondary bleeding again occurred to the extent of six ounces, and spots of commencing gangrene appeared on his arm. In the evening he died of exhaustion, induced by contamination of his circulating fluids by the gangrenous arm, assisted, in all probability, by the loss of blood. Illustrative case.

Case LXVII. *Gunshot Wound of Axillary Artery; Diffused Traumatic Aneurism; Secondary Hemorrhage on Tenth Day; Deligation of the Subclavian; Hemorrhage recurred Three Days afterwards; Consecutive Gangrene; Death; Autopsy;* reported by Henry G. Piffard, M. D., House Surgeon at Bellevue Hospital. — G. W., aged 31, born in the United States, and a police officer by occupation, was admitted to the Bellevue Hospital, service of Dr. William Henry Church, on the evening of June 3d, 1865.

About an hour before admission he inflicted a gunshot wound upon himself in an attempt at suicide. The weapon was a small policeman's revolver, and the ball conical. It entered near the edge of the left pectoralis major muscle, six inches below the top of the shoulder, and, passing through the axillary region, emerged at a point opposite its entrance, and about one and a half inches from the edge of the axilla. There was very slight hemorrhage from the wounds.

When first seen, there was a large tumor in the region of the pectoralis major muscle, due to the effusion of blood. The patient was unable to move the arm or hand of the injured side, and sensation in the forearm and hand was very much diminished, though not entirely lost. *There was no pulsation in the radial or brachial arteries.* The general condition of the patient was good, and he had not lost much blood, as was evidenced by a normal pulse at the right wrist.

June 4. — Condition good; no hemorrhage since admission; tumor at upper part of left chest somewhat diminished. At a consultation held to-day, it was decided "that no surgical interference was called for at present." The arm, being somewhat cold, was wrapped in cotton, and morphia (p. r. n.) given. *No pulse at the wrist.*

June 5. — Sensation in the arm almost normal, motion improving, and *a slight pulse may be detected.*

June 8. — He has continued to improve; slight healthy discharge from the wounds. *The pulse is almost as strong in the left as in the right arm.*

June 13. — Last night hemorrhage occurred from anterior wound to extent of sixteen ounces; arrested it by pressure. A consultation being again held, it was decided to place a ligature of reserve upon the subclavian, and then to enlarge the original wound, and search for the bleeding vessels. Dr. Church immediately proceeded to place the ligature around the subclavian in the third portion of its course (the patient having been previously etherized). The needle and silk were soon passed under the artery, but the ligature was not tied. The wound on the anterior surface of the chest was then enlarged, when, owing to the disorganization of the parts, and there being no hemorrhage to guide to the wounded vessel, it was found to be useless to continue the search for it. The ligature was then tied, the arm wrapped in cotton-wool, and whiskey with morphia administered.

June 14. — He has passed a comfortable night, and feels very well; slight fever; pulse 116.

June 16. — Last night hemorrhage again occurred from the original wound to the extent of six ounces. This morning he is very much worse. Pulse small and quick, 150 per minute. Covered with a cold sweat, and feels very weak. *Several spots of commencing gangrene on the arm.*

June 17. — Died at half-past eight, A. M.

Autopsy, Four Hours after Death. — The chest was opened, the clavicle removed, and the subclavian artery was traced from its origin outwards. The ligature was found applied to the vessel just after its emergence from behind the scalenus. By dissecting further, the axillary artery was removed, and, on examination, a wound of this vessel was discovered at a point corresponding with the second part of its course. *There was a large diffused traumatic aneurism occupying the axillary region*, together with the upper and outer portion of the anterior aspect of the chest.[1]

Comments. — In cases like the foregoing, wherein the axillary artery has been wounded by a gunshot projectile, and a diffused traumatic aneurism has been formed in consequence of it, attended with much tumefaction in the axillary region, the risk of inducing gangrene of the arm by tying the subclavian artery should always be considered by the surgeon before he proceeds to perform that operation. Such, at least, is the lesson inculcated by the unfortunate termination that attended the case whose history has just been narrated. Could not a more favorable result have been obtained in this case by the performance of the old operation? The author is inclined to believe, for reasons already expressed in his comments upon the case of Capt. Jordan,[2] and in his observations upon

[1] Vide *American Journal Medical Sciences*, Oct. 1865, pp. 395, 396.

[2] Vide Case XXXVII.

the surgical treatment of traumatic aneurism, that when the axillary artery is involved in this form of aneurism, secondary hemorrhage from the wounded vessel will be less likely to occur, and consecutive gangrene of the arm will be less apt to follow, if the old operation for the cure of aneurism be performed, than it will be if the lesion be treated by the method of Hunter, and a ligature be applied to the subclavian artery alone.

In the *eighth* place, secondary hemorrhage not unfrequently occurs in consequence of the imperfect closure of the breaches in wounded arteries. At first the bleeding is arrested spontaneously, but afterwards the adhesive process fails to close the traumatic orifice completely and permanently, either because the wounded vessel is imprisoned in a bony case, like the inferior dental canal, which holds it open at the place of injury, or because it is situated in a part or organ, the mobility of which is very great, as, for example, the tongue, and obstructs the healing process in the arterial wound. By imperfect closure of breaches in wounded arteries.

In the next two cases, secondary hemorrhage appears to have been occasioned by the incomplete closure of wounded arteries at the place of injury, in the way just mentioned.

Case LXVIII. *Gunshot Wound of Face with Fracture and Extensive Comminution of the Lower Jaw; Profuse Secondary Hemorrhage occurred Six Days afterwards, and was arrested by Deligation of the Left Common Carotid Artery; but he lost so much Blood before the Hemorrhage was stopped that he died on the Following Day, of Exhaustion; the Autopsy showed that the Bleeding occurred from the Left Lingual and Inferior Dental Arteries.* — Private William Reeves, Co. C, 76th N. Y. Vols., aged 22 years, was admitted to the Stanton U. S. Army General Hospital, May 11th, 1864, from the field. He had been wounded on the 6th of May in the battle of the Wilderness. He received a compound comminuted fracture of the lower jaw from a minie ball, which entered the left cheek about half an inch anterior to the angle of the jaw, and emerged at a point nearly opposite.

When admitted to hospital the orifice of entrance was seen to be small, while that of exit was large, being about three inches in its longest diameter. A large number of primary fracture splinters had already been extracted through the mouth and the orifice of exit.

Profuse secondary hemorrhage from the wound supervened on the day of admission, May 12, and he lost about twenty-four ounces of blood. It was arrested by tying the left common carotid artery. No anæsthetic was employed. He was much exhausted from loss of blood when the

operation was undertaken. It was attended with a good deal of shock, and he did not rally afterwards. He died at four o'clock on the morning of May 13, of exhaustion, occasioned mainly by the loss of blood. The operation was performed by Assistant Surgeon Geo. A. Mursick, U. S. Vols.

At the *autopsy* it was found that the hemorrhage proceeded from the left lingual and inferior dental arteries.

CASE LXIX. *Gunshot Wound of Internal Maxillary Artery, with Fracture of Superior Maxilla; Secondary Hemorrhage from Wound and Ligation of Common Carotid Artery on Sixteenth Day; Hemorrhage recurred on Third Day afterwards; arrested it by Plugs and Styptics applied in Original Wound; Death from Abscess of Brain Forty-one Days after Operation;* reported by Dr. W. W. Keen, Jr., Acting Assistant Surgeon, U. S. Army. — Corporal C., 29th Mass. Vols., aged 33, wounded at Gettysburg, July 1st, 1863, admitted to the Satterlee U. S. General Hospital, July 11th. A minie ball penetrated his face one inch and three quarters below the left eye, and lodged in the upper jaw-bone, just behind the first molar tooth, partially destroying the left palatine arch, knocking out the last two molars, and destroying the alveolar process to a corresponding extent. On the third day the ball fell into his mouth, and he secured it. He was attacked by secondary hemorrhage on the 7th and again on the 10th of July.

When admitted to hospital the patient was doing very well. He continued to improve until the morning of July 16th, when a considerable hemorrhage, evidently arterial, set in. It ceased on the application of cold water. At twelve M., another and severer hemorrhage occurred; plugged both anterior and posterior wounds with lint wet with a solution of alum and benzoic acid. At three P. M., another severe hemorrhage took place from both wounds and the nares, the latter, doubtless, through the antrum which had been traversed by the ball. It ceased spontaneously. At five P. M., another hemorrhage occurred from the insecurely plugged posterior wound, but it soon ceased spontaneously. At six P. M., a violent hemorrhage occurred from both wounds. The liquor ferri persulph. was tried without success. He had now lost a large quantity of blood (between twenty and thirty ounces) since morning. At 6.10 P. M., proceeded to ligate the left common carotid artery. The patient could neither be etherized nor lie down. So the operation was performed while he sat on the side of his bed. The artery was tied, without difficulty, just above the omo-hyoid muscle. On tightening the ligature, violent spasms of all the muscles took place, with syncope. The bleeding immediately ceased; he was placed in the recumbent posture, and some brandy administered. In a few seconds the spasms ceased, and his consciousness returned.

July 19. — *Hemorrhage from both orifices of the gunshot wound again*

occurred at five A. M. *and ten* P. M., *but ceased spontaneously in both instances.* For the purpose of arresting these recurring hemorrhages, it was decided to expose the antrum, and plug both it and the wound. *An incision was therefore made from the angle of the mouth, on the left side, towards the ear, two and a half inches long; the cheek was dissected upwards, and the anterior wall of the antrum, together with the inferior boundary of the wound, was removed or cut away with the osteo-tome and scalpel. The loose pieces of bone were extracted, and the wound and the antrum, now one common cavity, were firmly plugged with lint saturated with Monsel's solution.* He was placed upon the use of nutrients, stimulants, and anodynes, and tinct. ferri chlorid. gtts. xx., with quiniæ sulph., grs. ii., t. d., were prescribed.

July 21. — The ligature came away from the carotid this morning, four and a half days after its application.

July 31. — Still decidedly improving; removed the plug of charpie from the jaw; there had been no hemorrhage in twelve days; pulse ninety-six.

August 1, 2, *and* 7. — Hemorrhage recurred from the wound of the face; stopped it by plugging the antrum as on a previous occasion.

August 20. — Hemiplegia of right side.

August 22. — Convulsive movements of right or paralyzed side.

August 26. — Died at eleven A. M. to-day, comatose; fifty-six days after being wounded, and forty-one after the operation.

The *autopsy* showed that the left carotid artery was consolidated from within three fourths of an inch of the aorta up nearly to its bifurcation, where it again became patulous; and that the left cerebral hemisphere was involved in suppurative inflammation.[1]

In the *ninth* place, secondary hemorrhage not unfrequently occurs from the distal orifice of a wounded artery, and is produced by the imperfect closure of said orifice, the proximal orifice being at the same time well sealed up. We have already seen secondary bleeding occur in this way in the case of Christopher Gross (No. XII.). He had sustained a gunshot wound of the thigh, which severed the femoral artery. Both ends of the divided vessel were secured by ligatures applied on the field of battle. The vein also was tied. Secondary hemorrhage, from the distal part of the artery, occurred on the sixth and again on the ninth day. It was controlled by pressure. The patient was in a dying condition from loss of blood and commencing gangrene of the limb, and no operation was therefore attempted. In Case No. LII., the secondary flow of blood proceeded also from the distal orifice of the wounded common carotid artery. The

From distal orifice of wounded arteries.

[1] Vide *American Journal Medical Science*, July, 1864, pp. 27–32.

proximal orifice was, at the same time, still plugged with the impacted ball that had produced the injury.

Scurvy promotes the occurrence.

In the *tenth* place, it has been found that *scurvy* exerts an important influence in the production of secondary hemorrhage. All surgeons who have given attention to the subject appear to be agreed on this point. The scorbutic taint promotes the occurrence of secondary after-bleeding, — *firstly*, by the thin, watery condition, and diminished coagulability of the blood with which it is accompanied ; and, *secondly*, by the enfeebled tone and enfeebled power of the systemic reparative forces which it always induces. Hence it is that secondary hemorrhage occasioned by scurvy is met with, in a very large proportion of the cases, on the fifth, sixth, and seventh days, or, in other words, during the early part of the secondary period.

The following case presents us with an example of secondary scorbutic hemorrhage. The bleeding was arrested by ligatures applied on both the proximal and distal side of the wound of the brachial artery. The patient recovered. This case was contributed by Dr. W. Clendenin, late Surgeon U. S. Vols. : —

CASE LXX. — *Scorbutus ; Gunshot Wound involving Brachial Artery ; Secondary Hemorrhage on Sixth Day ; arrested by Ligation of Artery at Seat of Injury, both Proximal and Distal ; Reference also made to Thirteen Additional Cases of Scorbutic Hemorrhage.* — ——— ———, of the 69th Reg., O. V. I., was wounded through the fleshy part of the left arm, on its inner aspect, near the middle, which was attended with very little hemorrhage. Pulsation was absent in both the radial and ulnar arteries ; temperature of the hand and fore-arm reduced. The patient was laboring under slight indications of scorbutis. The wound was dressed with lint and water dressings ; and the hand and fore-arm were enveloped in flannels with a view to the preservation of a normal temperature therein. A generous diet, consisting of beef-soups, milk, and vegetables, was allowed. On the sixth day after the receipt of the wound, hemorrhage suddenly supervened, and was controlled only by compressing the brachial artery. The wound was dilated, and a ligature placed upon both the proximal and distal side of the injury of the vessel. The bleeding did not again occur.

Scorbutic hemorrhage from ulnar and radial arteries.

In *four* cases of flesh-wounds of the *fore-arm*, implicating the ulnar artery, occurring in men of scorbutic taint, secondary hemorrhage occurred in one case on the fifth day, in one case on the sixth, and in the other two cases on the seventh day subsequent to that of injury.

In each of these cases the ligature was applied at once, and the hemorrhage permanently arrested. Recovery in all complete.

In *three* cases of gunshot injury of the fore-arm in which the radial artery had undoubtedly been severed (the patients manifested symptoms of scurvy), hemorrhage was continuous from the very moment the wounds were received until ligatures were applied, and it was restrained only by compression, made both above and below the point of injury. In one of these cases the artery was not ligated until the evening of the fifth day, when the patient became unwilling to undergo compression longer, and ligatures were put upon the distal and proximal sides of the injured vessel by *dilating the original wound*; in the other two cases ligation was effected, as in the first case, on the third day. Dr. Clendenin's contribution continued.

Six cases of secondary hemorrhage from the posterior tibial artery came under my observation, all of which, in my opinion, had their origin in scurvy; that is to say, I do not think it probable that secondary hemorrhage would have ensued, if the men had not been scorbutic. The bleeding occurred in one case on the fourth, in three on the fifth, in one on the sixth, and in the sixth case on the seventh day after the infliction of the wound. In two of these cases the ligatures sloughed off within four days after they were applied, and ligation was subsequently successfully effected (in the lower part of the upper third of the leg) above the point of injury. From posterior tibial artery.

Dr. Clendenin also observes, — I have never witnessed secondary hemorrhage from the anterior tibial artery, excepting as a result of hospital gangrene.

Upon secondary hemorrhage occurring in scorbutic subjects, and as germane to this topic, we will here introduce the following: —

Surgeon John Wilson, U. S. Vols., states that he has "long been of the opinion that depravation of the blood is the prolific source of this hemorrhage;" that it "generally occurs in patients whose vital status is below par, and whose wounds show no efforts at reparation, but, on the contrary, remain patulous, frequently giving issue to a gray, shreddy, and sometimes sanious and fœtid discharge." "In all these cases" he conceives "the hemorrhage to result from a lack in the formative power of the system generally, or in the part specially." After the application of a ligature to a wounded artery, he considers that "the risk of secondary hemorrhage will be exactly in proportion to the power of plastic reformation." "Without this power the ligature will very often fail to protect the patient; destructive disintegration will set in, and the feeble barrier which nature may have attempted to erect against the flood, will yield before the *vis a tergo*, and the hemorrhage recur." Dr. J. Wilson on causes of secondary hemorrhage.

"Other cases of bleeding occur where no primary breach of continuity exists, and where the bleeding proceeds from vessels involved in the destructive process of sloughing subsequently occurring in the wound."

"For all these classes of secondary hemorrhage," he conceives "*proteine* in some form" "to be the surest remedy." He believes "albumen to be the *prophylactic styptic par excellence*, — not applied to the wound, but introduced freely into the living economy." "Compared with this," he deems "all other agents scarcely worthy a serious consideration."[1]

Dr. Wilson was afterwards appointed one of the medical inspectors of the army.

In the *eleventh* place, secondary hemorrhage is sometimes induced by the injuries attendant upon the transportation of the wounded, which is an inseparable concomitant of the practice of surgery with armies in the field.

By injury in transportation.

Guthrie relates the following case in point: —

Guthrie's case.

Private J. Barnes was wounded May 16, in the right thigh, by a musket-ball, which divided the femoral artery as it becomes popliteal. The hemorrhage, which was at first very profuse, ceased spontaneously. Afterwards the toes were attacked with gangrene.

On the evening of June 3, eighteen days after the casualty, this patient was placed on a bullock-car, to be removed with the rest of the wounded to Elvas; the mortification of the foot having ceased to spread, and a line of separation having been formed. Shortly after the cars moved, he learned that the man was bleeding from the wound; the blood evidently came from the popliteal artery, and, as it flowed slowly, he supposed from the lower divided end. Guthrie amputated the limb above the knee, and, on dissecting it afterwards, found that the divided ends of the artery were separated from each other to the extent of an inch, that the proximal portion contained a firm coagulum nearly an inch long, which filled up the contracted mouth of the vessel like the gradual diminution of the neck of a claret-bottle; a layer of the same covered the mouth of the vessel and its immediate vicinity, and appeared to have a commencing organization. The vein was closed in the same manner. The distal portion of the artery was very peculiar. *The substance drawn across appeared to have closed it completely at one time, and to have given way from the rough motion of the car at the point found open*, which was very small, even when the sides of the artery were approximated. *A very little soft coagulum was behind it; and, if the patient had not been removed*, Guthrie *thought the vessel would have remained secure.*[2]

The foregoing account of the case has been considerably abridged from that published by Guthrie.

[1] Vide *American Medical Times*, June 13, 1863, p. 279.

[2] Vide *Diseases and Injuries of Arteries*, pp. 233, 234, 235.

In the *twelfth* place, it appears that the occurrence of secondary hemorrhage is promoted by the operation of moral causes of a depressing nature. Promoted by moral causes.

Concerning the Influence of Moral Causes in producing Secondary Hemorrhage; transcribed from the author's field note-book. — Wednesday, April 26, 1865, in camp near Burkesville, Va. Acting Staff Surgeon Albert Wood, who has just now returned from City Point, reports that there has recently been a good deal of secondary hemorrhage among the wounded in the Cavalry Corps Hospital at that place, and that, relatively, a much larger proportion of it has fallen upon the commissioned officers than upon the enlisted men. The medical officers of the Cavalry Corps Hospital were inclined to attribute this disparity, which was very striking, to moral causes in great degree. The enlisted men who were able to bear transportation, were not retained in the hospital at the Point, but were sent northward and homeward by the hospital steamers with but little delay. With the commissioned officers, however, the case was different. They experienced great difficulty and much delay in procuring leaves of absence, notwithstanding that they were suffering from wounds received in battle. Without a leave of absence granted by competent authority, they were not permitted to leave City Point. While they were, for the most part, extremely anxious to visit their homes, they were retained in the Depot Field Hospital (cavalry portion of it), apparently without any good reason. In consequence of this neglect, many of them became melancholy, and a good deal depressed in both spirits and strength. This intense anxiety to revisit their families continuing day after day, with hope deferred, told badly on their general health after a time, and operated indirectly as a cause promotive of secondary hemorrhage. Such, at least, according to Surgeon Wood, was the explanation offered by the medical officers on duty at the Cavalry Corps Hospital, for the purpose of accounting for the relative greater frequency of the occurrence of secondary hemorrhage among the commissioned officers than among the enlisted men, and, indeed, it appears to be about the only sound reason that can be presented. Notes on moral influences.

Again, certain preëxisting pathological conditions of the arterial tunics, such as atheroma, fatty degeneration of all kinds, and ossification, exert no inconsiderable influence in the way of predisposing to the occurrence of secondary hemorrhage after wounds and surgical operations involving arteries of considerable size, whose walls are thus diseased. Mr. Paget, in a recent clinical lecture, says, with regard to amputation in cases belonging to this category, — Atheroma and ossification of arteries.

"Here one can have no doubt that degeneracy of the arteries in the

limb brings great peril with it. Primary hemorrhage is more difficult to control, and recurrent and secondary hemorrhages are more frequent, and all the worse because the patients are those in whom all losses of blood are dangerous. Moreover, if these risks are survived, the feeble nutrition of the wounded parts gives opportunity for spreading suppurations; and all the healing processes are slow; and hereby all the perils of the case are prolonged. And when you think of slow healing of any amputated limb, remember that amongst all the textures of the limb few are less favorably constructed for healing than are the tissues of the arteries. Their healing after wounds is, as you know, difficult, and often interrupted, even in the healthiest persons. Much more likely is it to be so in those whose textures are degenerate; indeed, if you look at a thoroughly degenerate artery, you must wonder that healing should ever take place."[1]

Important point.

There is an important point relating to secondary hemorrhage that has already been briefly alluded to, which demands some additional consideration; namely, when secondary hemorrhage occurs from an artery wounded or tied in its continuity, — for example, the femoral artery in the continuity of the thigh, — the distal orifice or part of the vessel is generally the source of the bleeding. In cases belonging to this category, it is usually found that the proximal orifice remains securely closed, while the distal orifice, even when it was closed at the outset, becomes reopened from failure of the healing process in that part of the artery.[2] There can be but little doubt that the distal end of a divided artery is more prone to bleed during the secondary period than the proximal. When an artery is tied in its continuity, the distal clot is always found to be much smaller than the proximal.[3] The organizing process also proceeds less rapidly in the distal than in the proximal coagulum. The healing process generally is much less active on the distal than on the proximal side of a ligature, in the tissues of the artery. The blood which escapes from the distal orifice is usually dark-colored, and flows in a steady stream, except in certain regions where the inosculation between the terminal branches is very free, for example, in the scalp and in the fore-arm, as already mentioned.[4] It is obvious that when hemorrhage occurs from the distal orifice, whether it be primary, intermediary, or secondary, it does no good to compress or tie the injured vessel on the proximal side of the wound, and the surgeon should constantly

[1] Vide *Lancet*, Aug. 10, 1867; also *Medical News*, Nov. 1867, p. 164.

[2] See case of Christopher Gross, No. XII.; also two cases related by Guthrie, in which fatal hemorrhage occurred from the distal end of a divided artery, *op. cit.*, pp. 252, 253.

[3] See Case of Sergt. Ferguson, No. LXIV.

[4] Vide page 5 of this essay.

be alert lest he may commit this error, which happened to so eminent a surgeon as Pelletan.

Moreover, secondary hemorrhage, whether occurring from the distal or the proximal orifice of injured arteries, or from the stumps of amputated limbs, or from wounds in their continuity, generally implies some defect in the healing process, — some deficiency in either the organizing force or the organizing material. This statement obtains in a large majority of the instances where secondary bleeding takes place. It is also a subject of considerable importance in a practical point of view, because, not unfrequently, this defect in the healing process may be anticipated and remedied to considerable extent by appropriate medication. If, for example, the subject of a severe wound or surgical operation has scurvy, or malarial disease, or constitutional syphilis, or happens to be much reduced from want of food or loss of blood, suitable alimentation, combined with the administration of remedies calculated to remove the diathetic disorder (dyscrasia) generally assists to prevent the occurrence of secondary hemorrhage, by promoting the healing process in the wounded vessels. Again, much good may also be done by securing thorough cleanliness and ventilation. Secondary hemorrhage is always much more rife among the inmates of the over-crowded and noisome hospital wards than among those of the well-ventilated and cleanly ones. During the late War of the Rebellion, the most efficacious of the means at our disposal for preventing secondary bleeding consisted in the administration of nutrients, anti-scorbutics, anti-periodics, tonics, and stimulants, as indicated by the special features of each case, and in the avoidance, as far as practicable, of all those disorders which are engendered by foul air and uncleanliness, or produced by hospital infection.

What secondary hemorrhage generally implies.

Prophylaxis of secondary hemorrhage.

It has been deemed advisable to present, in a tabular form, Professor Eve's interesting collection of cases in which secondary hemorrhage occurred.

CASES OF SECONDARY HEMORRHAGE OCCURRING IN THE GATE CITY HOSPITAL (CONFEDERATE), AFTER THE BATTLE OF CHICKAMAUGA, SEPTEMBER 19TH AND 20TH, 1863. CONTRIBUTED BY PAUL F. EVE, M. D., SURGEON IN CHARGE.

No.	Names.	Regiment.	Co.	Wound.	Date of same.	Hemorrhage.	Artery.	Result.
1	Golden, O. P.	1st So. Ca.	G.	Ball fracturing both bones of right leg	Sept. 20	Amputation. 9th Oct. Has typhoid fever; stump sloughed	Posterior tibial artery. 19th Oct. Amp. thigh	No reaction after operation. Died in ten hours.
2	Hembery, A. J.	4th Ala.	K.	Ball through lower portion of popliteal space	" 19	1st Oct. Amputation just above knee	Popliteal, about its division	Doing well for two days, then severe rigors. Death, end of 3d day.
3	Butler, W. M.	7th Ark.	K.	Ball through right foot . .	" 20	3d Oct. Pirogoff. Amputation. Foot	Plantar arch	Doing pretty well.
4	Underw'd, W.E.	30th Tenn.	E.	Ball through left elbow-joint .	" 20	18th Oct. Amputation. Middle humerus	Probably the anastomotica magna . . .	Doing well. Up in the ward.
5	Ponts, Peter	13th and 20th La.	C.	Ball through right thigh . .	" 20	Oct. 6th. Opened the wound. Patient very low. Did not find the bleeding point . .	Probably the profunda .	Died, Oct. 9th, 1863.
6	Sherrill, L. T.	18th Ala.	K.	Ball through right nates . .	" 20	9th Oct. Restrained by pressure	Gluteal	Died, 11th Oct., 1863.
7	Clingham, P. J.	2d Ark. M.R.	F.	Ball through both thighs . .	" 19	2d Oct. Right thigh. Restrained by pressure	Branches of profunda .	Tolerably. Some sloughing from tourniquet. He died a month after this date.
8	Kelly, James	10th Tenn.	I.	Ball lodged below right elbow. Extracted 28th September .	" 19	2d Oct. Amputation. Arm .	Radial	Up and doing well.
9	Stanford, Sclo.	34 Tenn.	H.	Ball lodged in left thigh, fracturing femur	" 19	7th Oct. Has diarrhœa — of which he died	External circumflex. After breaking femur the flattened ball was found near trochanter in post-mortem examination .	Died, 27th October.
10	Wright, Andrew	9th Ky.	H.	Ball through right ankle . .	" 19	About the 1st of October. Amputation of leg	Anterior Tibial . . .	Doing well. Left Hospital 30th. Transferred.
11	Morgan, Samuel	25th Ala.	H.	Ball through right ankle . .	" 19	About 28th Sept. Pressure .	Dorsalis pedis	Doing well.
12	Moore, S. L.	18th Tenn.	F.	Amputation of arm on field .	" 19	From sloughing and pressure .	Of stump	Doing well.

13	Harrison, G. D.	30th Ga.	G.	Ball through left leg, with fracture of bones	Sept. 20	Was ill when received; had jaundice	Anterior tibial	Died 3d day after hemorrhage, which was profuse.
14	Higgins, Chas.	41st Miss.	C.	Right arm shattered	" 20	About the 28th Sept. From sloughing. Amputation of shoulder-joint. 28th Sept.	Brachial	Died, 6th of Oct., of pyæmia.
15	Wells, Samuel	28th Tenn.	A.	Ball through right arm . . .	" 19	Stopped by pressure	Brachial	Up and about.
16	Grant, W. H.	1st So. Ca.	F.	Ball through ankle	" 19	Stopped by pressure	Tibial posterior . . .	Doing well.
17	Gray, J. Lieut.	25th Ark.	H.	Ball through thighs	" 20	Stopped by pressure	Branch femoral profunda	Doing well.
18	Mooneyham, D.	35th Tenn.	C.	Ball lodged in thigh	" 20	Pressure	Popliteal, 29th Oct.	Doing tolerable. No recurrence.
19	Lush, J. M.	4th Ala.	C.	Ball through scapula. Extracted about 1st Oct., with forceps at sterno-clavicular junction	" 20	Hemorrhage, 17th Oct., from the wound excited by getting up	Some pressure was used, it probably stopped spontaneously . . .	Doing only tolerably well. Has frequent rigors and profuse sweats. I think this patient died.

Prof. Eve remarks, "I give above the particulars (as far as could be ascertained at this period), with the aid of the assistant surgeons, etc., of nineteen cases of secondary hemorrhage. But I am pretty certain this does not embrace all the cases which have occurred, and presume we must have had from twenty-five to thirty. The hemorrhage in these cases took place in all, I think, from ulceration of the arteries; at any rate, it was manifest during the sloughing process.[1]"

[1] Due no doubt to cachexia from scurvy.

CHAPTER ELEVENTH.

ON THE SURGICAL TREATMENT OF TRAUMATIC HEMORRHAGE, ESPECIALLY THE SECONDARY FORM OF IT.

The Ancient Surgeons on the Treatment of Traumatic Hemorrhage: 1st, Celsus; 2d, Galen; 3d, Aëtius; 4th, Palladius; 5th, Albucasis; 6th, Averrhoes; 7th, Avicenna; 8th, Rhases; 9th, Haly Abbas; 10th, Paulus Ægineta. — The Early Modern Writers on Surgery mention all the Ancient Methods of suppressing Hemorrhage: 1st. Of *Pressure* as a Means of arresting Hemorrhage. — How it should be applied to restrain Venous Hemorrhage. — In what Cases Pressure should be employed to suppress Arterial Hemorrhage. — How it should be applied to restrain Bleeding from Large Arteries when wounded. — But Little Force required to suppress Arterial Hemorrhage when directly applied. — The Author's Experience on this Important Subject. — Pressure must not be looked upon as a Substitute for the Ligature. — It generally fails to arrest the Bleeding permanently when Important Arteries are wounded. — But it is often a Useful Adjuvant. — 2d. Of *Certain Astringents* as Hæmostatic Agents. — Our Army Surgeons have placed Most Confidence in the Persulphate and the Perchloride of Iron. — The Cases in which they have been found useful. — Objections to their Indiscriminate Use already stated. — 3d. Of the *Actual Cautery* as a Means of arresting Secondary Hemorrhage. — The Hot Iron successfully employed when the Parts were sloughing. — An Illustrative Case contributed by Dr. Clendenin. — Gunshot Wound of Leg; Secondary Hemorrhage on Fifteenth Day; it recurred Three Times; Wound unhealthy; Bleeding controlled at first by Pressure alone; Next Pressure and Liquor Ferri Persulph. were tried, but without Success; then the Actual Cautery arrested the Bleeding; Recovery. — Dr. Clendenin's Experience favorable to using the Actual Cautery for suppressing Hemorrhage from Sloughing and Gangrenous Wounds. — Another Case. — Gunshot Wound of Right Buttock penetrating Pelvic Cavity; Secondary Hemorrhage commencing on Twelfth Day; Pressure and Astringents tried without Success; Actual Cautery also unsuccessful. — Why it failed in this Case. — The Actual Cautery more reliable as an Hæmostatic Agent than Pressure and Astringents. — It is well adapted to the Treatment of Hemorrhage occurring in Sloughing and Gangrenous Parts. — 4th. Of *Torsion* as an Hæmostatic Procedure. — It is an Expedient of Minor Importance for the Suppression of Arterial Hemorrhage. — 5th. Of *Amputation* as an Operative Procedure which may sometimes be rendered necessary by Secondary Hemorrhage. — It was one of the Principal Expedients employed by the Ancients for the Relief of Hemorrhage occurring in the Extremities. — The Cases in which it is still employed for that Purpose enumerated. — 6th. Of the Ligature as a Means of suppressing Hemorrhage. — An Illustrative Case contributed by Dr. Clendenin. — Gunshot Wound of Upper Part of Neck; Bullet passed through from Side to Side; Secondary Hemorrhage on Fourteenth Day; it was treated by Pressure; it recurred Several Times, and finally terminated in Death; Interesting Reflections by Dr. Clendenin; Important Statements by the same Writer concerning other Cases of Secondary Hemorrhage wherein Pressure and the Persulphate of Iron had failed, but which were finally saved by Ligation. — The Ligature the most reliable of all the Means at our Disposal for the Arrest of Secondary Hemorrhage. — Eight Instances mentioned in which Compression failed, the Brachial Artery being wounded. — Guthrie's Direction not to tie a Wounded Artery unless it Bleeds at the Time is far too broad and undiscriminating. — Fatal Consequences of this Policy in the Case just related. — Good Results of a Different Policy in other Cases. — The Ligature employed on Three Distinct Plans for the Arrest of Arterial Hemorrhage. — They are enumerated: 1st, the Old Plan; 2d, that of Anel; 3d, that of Hunter. — A Case contributed by Dr. Leale. — Gunshot Wound of Leg fracturing Fibula and severing the Posterior Tibial Artery; Secondary Hemorrhage commencing on Tenth

Day; Pressure and Astringents failed to arrest it; Old Operation performed; Hemorrhage permanently suppressed, but Death ultimately occurred from Pyæmia. — Pyæmia results not unfrequently from Wounds of Arteries. — A Case contributed by Dr. Clendenin in which Secondary Hemorrhage was successfully treated by tying the Artery on the Plan of Anel. — Gunshot Wound of Cheek, Tongue, and Throat; Secondary Hemorrhage on Seventh Day from Mouth; Astringents failed to arrest it; Ligation of Lingual Artery which stopped the Bleeding, and it did not return. — A Case contributed by Dr. Heise in which Secondary Bleeding occurring in a Stump was successfully treated by tying the Main Artery on the Plan of Anel. — Gunshot Fracture of Thigh involving Knee-joint; Amputation; Secondary Hemorrhage from Stump on Twenty-third Day afterwards; ligated the Femoral Artery in Scarpa's Space, which arrested the Bleeding permanently; Recovery. — The Old Operation is generally to be preferred in treating Secondary Hemorrhage. — To what Cases the Plan of Anel is Applicable. — Dr. David P. Smith's Contribution on Secondary Hemorrhage. — An Account of Four Cases successfully treated. — 1st. In this Case the Brachial Artery was tied on the Plan of Hunter. — 2d. In this Case the Common Carotid was tied on the Plan of Hunter. — 3d. In this Case also the Common Carotid was tied on the Plan of Hunter. — 4th. In this Case the Femoral was tied on the Plan of Hunter. — Guthrie's Rule to tie every Artery at the "Bursten Point" cannot always be followed. — A Case contributed by Dr. Clendenin. — Gunshot Wound of Mouth and Neck; Secondary Hemorrhage on Eighteenth Day; Ligation of Common Carotid Artery; Death Three Hours afterwards by Coma. — On Cerebral Mischief as a Consequence of tying the Common Carotid Artery. — The Fatality of this Operation very great. — The Common Carotid should not be tied in Cases where the Ligation of the External Carotid or its Branches will arrest the Bleeding. — A Case contributed by Dr. B. Howard. — Gunshot Wound of Neck followed by Secondary Hemorrhage; Ligation of Common Carotid Artery; Result not stated. — A Case contributed by Dr. Leale. — Gunshot Wound of Thigh; Secondary Hemorrhage; Ligation of External Iliac Artery; The Bleeding recurred, but it was controlled by Pressure; Pyæmia supervened; Result not stated. — A Case which occurred in the Practice of Prof. Brainard. — Ligature of Common Iliac Artery for Secondary Hemorrhage from Gunshot Wound of Thigh near Pelvis; Recovery from Operation, but Death occurred Three Months afterwards from Typhoid Fever. — Gunshot Wound of Thigh (Lower Third) involving Femoral or Popliteal Artery; Vessel tied in Tendinous Canal of the Adductor Magnus; Secondary Hemorrhage; then tied Femoral Artery at Apex of Scarpa's Triangle; Death occurred some Time afterwards (Two Months). — Secondary Hemorrhage from Stump after Amputation at the Shoulder-joint; Bleeding very profuse and repeated; arrested by Pressure on the Subclavian; Recovery. — The Ligation of the Subclavian would have been preferable in this Case. — The Reasons stated. — Secondary Hemorrhage occurring in Stumps should be treated on somewhat Different Principles from those which obtain when it occurs in the Continuity of the Extremities. — The Reasons stated. — *Conclusions concerning the Employment of the Ligature for restraining Hemorrhage.* — A pretty Full Summary given. — Why the Metallic Ligature is generally to be preferred. — 7th. Of *Acupressure* as an Hæmostatic Agent. — Dr. Otis' Remarks on this Subject. — Surgical Hemorrhage not relieved by the Internal Administration of Astringents.

THE following means are employed by surgeons for the purpose of arresting the flow of blood from wounded vessels: —

1st. *Local pressure*, applied at the place of injury.

2d. *Styptics*, such, for example, as the vegetable and mineral astringents, including tannin, nut-gall, plumbi acetas, ferri persulphas, and ferri perchlor., together with cold in the form of ice, freezing mixtures, etc.

3d. *The actual cautery* applied to the bleeding orifice and the tissues surrounding it.

4th. *Torsion* of the mouth of the bleeding vessel.

5th. *Amputation* of the member above the place of injury and the source of the hemorrhage.

6th. *Ligation*, —

a. By the old operation, which consists in the application of two ligatures to the wounded artery at the place of injury, one on the proximal and the other on the distal side of the orifice in its walls.

b. By the method of Anel, whereby the wounded artery is secured with only one ligature, applied between the place of injury and the heart, but as near to the former as it can conveniently be done without tying in the original wound.

c. By the method of Hunter, which consists in arresting the flow of blood in the wounded artery, by applying a ligature to the main vessel between the place of injury and the heart, but at a considerable distance from the former.

7th. *Acupressure*, as recommended by Sir James Y. Simpson.

Ancient surgeons on treatment of traumatic hemorrhage.

The ancient surgeons appear to have been well acquainted with the proper treatment of traumatic hemorrhage, although a different statement of this point is often made in modern works on surgery.

Celsus directs the employment of cold and pressure combined, of the ligature, of caustics, escharotics, and even the actual cautery, for the purpose of arresting arterial hemorrhage.

Galen recognizes as means of restraining the flow of blood from a wounded vessel: 1st, local pressure applied with the finger; 2d, torsion; 3d, complete division; 4th, ligation; 5th, actual cautery. Ligatures, he says, should not be applied to veins to stop bleeding, but styptics should be employed. He treats of the subject of hemorrhage from wounded arteries and veins at great length.

Aëtius discusses the subject in the same terms as Galen, and recommends the ligature under the circumstances mentioned by him.

Palladius says, we often stop the bleeding by applying a ligature to the divided vessel.

Albucasis mentions four methods of arresting hemorrhage from a wounded artery: 1st, the actual cautery; 2d, the cutting of the vessel completely across; 3d, ligation; 4th, styptics applied on a compress with a tight bandage.

Averrhoes recommends the use of styptics, the cautery, and the ligature to suppress bleeding. He states distinctly that the bleeding vessel must be secured with a thread, when the hemorrhage cannot be stopped by other means.

Avicenna treats of all the modes of arresting hemorrhage with

singular accuracy, and at great length. He mentions the application of cold, of escharotics, and of the actual cautery. He also speaks of the complete division of the wounded artery, the ligation of it with a "flaxen thread," and the application to it of pressure by means of a compress and a bandage tightly applied, when the ligature cannot be employed. His description of the process by which an artery is ligated "has quite a modern complexion."

Rhases mentions the application of snow, torsion, ligation, styptics, and cutting the wounded vessel completely across. He states that Galen *approved of the employment of two ligatures in certain instances, of which one should be applied on each side of the wound in the artery, because it sometimes happens that the inferior portion will pour forth blood (distal, or recurrent hemorrhage).*

Haly Abbas gives an interesting account of hemorrhage, and makes mention of bandages and the ligature.

Paulus Ægineta mentions the value of posture in arresting hemorrhage, and of compressing the vessel with the finger at the wounded part of it, so as to stop the flow of blood and get a thrombus. He also speaks of torsion and the ligature. He says that an effort should be made to stop the bleeding from wounded veins without tying them, — by using styptics and pressure. If the hemorrhage come from a wounded artery, he says, one of two things must be done, either the vessel must be secured with a ligature, or it must be cut asunder. Sometimes it is necessary to apply a ligature to large veins. He states that hemorrhage from a wounded artery may be distinguished from venous hemorrhage, because the blood of an artery is brighter and thinner, and is evacuated by pulsations, while that of a vein is blacker and without pulsation.[1]

The early modern writers on surgery mention all the ancient methods of stopping hemorrhage. Guy of Cauliac recommends the ligature upon the authority of Galen and Avicenna. It is also recommended by Brunus, Theodoricus, Rolandus, and Lanfrancus. It appears, therefore, that the use of the ligature for arresting hemorrhage was well understood by the ancients, and has never been lost sight of even in the darkest ages.

Early modern writers.

1. *On Pressure as a Means of arresting Hemorrhage.* — When bleeding occurs from veins that have been wounded in their continuity, pressure applied to the wound with a compress and roller bandage generally suffices for its suppression.

Pressure in venous hemorrhage.

[1] Vide *Paulus Ægineta*, vol. ii. pp. 128, 130, *et seq.* Sydenham Soc. ed.
[2] *Op. cit.*, vol. ii. p. 132.

The statement is made in Circular No. 6, with regard to gunshot wounds of veins, as already mentioned, that "no cases have been reported in which the bleeding could not be controlled by pressure." [1] Two cases, however, have been related in these pages which proved fatal from repeated hemorrhages.[2] When much pressure is employed to arrest the flow of blood from a wounded vein, it is generally advisable to apply a roller bandage evenly, smoothly, and firmly to all of the limb below, or on the distal side of the place of hemorrhage, as already recommended.[3]

Pressure in arterial hemorrhage.

With regard to wounded arteries, pressure may often be advantageously employed to restrain hemorrhage, provided the vessels are small in size, and completely divided at the place of injury. In such cases pressure generally arrests the bleeding permanently. But local pressure has also been temporarily employed with striking advantage for the suppression of hemorrhage from large arteries, such as the femoral, the axillary, and the carotid. It is related on page 13 that an officer belonging to the Army of the Potomac, who had received a gunshot wound involving the femoral artery, restrained the bleeding with his own fingers applied in the wound until he was brought to a surgeon, and had the artery tied. In a case related to the author by Dr. Azpell, digital compression of a wounded axillary artery was successfully employed until a ligature could be applied to the subclavian artery. In the case of General Arrighi, reported by Baron Larrey, the right carotid artery was wounded by a musket-ball, and the hemorrhage must have inevitably proved fatal, if a soldier had not introduced his two fore-fingers into the wounds, and arrested the bleeding until Larrey arrived, and tied the vessel. And, again, in the case of Lieut. Van Giesen, reported by Dr. Hunt,[4] wherein the external carotid artery was wounded by a pistol-ball, the victim was saved from impending death by compression of the bleeding orifice in the vessel, effected by inserting the thumb into the wound. All of these patients recovered.

Pressure in bleeding from large arteries.

But little force required when directly applied.

With regard to the amount of force required to prevent the escape of blood from a wounded artery of even a large size, I have often been surprised at finding by experiment how little it is when directly applied. Thus, in amputating the thigh, I have several times noticed that the escape of blood from the severed femoral artery could be completely arrested by applying the finger but *lightly* to its open

The author's experience.

[1] Page 39.
[2] Vide Cases XLV. and XLVI.
[3] See Wounds of Veins.
[4] Vide Case XXVIII.

mouth. I have also observed on several occasions that a small degree of pressure applied to the sides of the same vessel sufficed to stop the escape of blood from its open mouth. Once, in operating for carcinoma of the breast, it happened to me to unexpectedly find the deep axillary glands very much enlarged and diseased. Their removal was necessary. It was accordingly done; and the sheath of the axillary artery, on its lower side, was laid completely bare thereby, for a considerable distance. I compressed the artery laterally with my fingers, and likewise by pressing it upwards against the shoulder-joint, and was again surprised to find how little force was required to stop the pulsations of, and arrest the flow of blood through the axillary artery. I called the attention of the medical gentlemen who assisted me in performing the operation, to this circumstance. But the credit belongs to Guthrie of first calling the attention of the profession to the subject.

Pressure or compression, however, must not be looked upon as a substitute for the ligature in cases of hemorrhage from wounded arteries. The reader will recollect that in Case XXX. reliance was placed on local pressure for the purpose of controlling the bleeding from a wounded occipital artery, and that it signally failed to do it. This fact should be borne in mind by every surgeon, that, although pressure has occasionally proved successful in permanently arresting hemorrhage from important arteries when wounded, it has generally failed, especially when the vessel involved had a large size. In such cases repeated hemorrhages have generally occurred, and the patient, in almost every instance, has ultimately died of exhaustion from loss of blood. But pressure may oftentimes be usefully employed as an adjuvant to other measures.

Not a substitute for the ligature.

Often a useful adjuvant.

2. *Of Certain Astringents as Hæmostatic Agents.* — The articles belonging to this class, upon which most reliance seemed to be placed by our army surgeons during the late war, were the persulphate and the perchloride of iron. They were found to be useful in arresting parenchymatous hemorrhage occurring during the primary period, in tissues suffering from acute inflammatory œdema, in stopping bleeding from small arteries, in suppressing hemorrhage occasioned by the ulceration of small arterial twigs in the cavities of deep-seated abscesses, and, conjoined with the local application of ice, they were often found to be successful in arresting secondary bleedings from stumps that were small or moderate in quantity, and probably not connected with

Persulphate and perchloride of iron.

the main artery. The principal objections to the employment of these styptics have been stated elsewhere.[1]

Not frequently employed.

3. *Of the Actual Cautery as a means of arresting Secondary Hemorrhage.* — This agent was successfully employed by some of our military surgeons for the purpose of suppressing this form of bleeding when it occurred in the midst of tissues that were sloughing, and the coats of the wounded artery were so much weakened that they would not hold a ligature.

Case contributed by Dr. Clendenin.

The actual cautery was successfully employed in the following case of secondary hemorrhage from an unhealthy wound, which has been contributed by Dr. W. Clendenin, late Surgeon U. S. Volunteers.

CASE LXXI. *Gunshot Wound of Leg; Secondary Hemorrhage on Fifteenth Day; it recurred Three Times afterwards; Wound unhealthy; Bleeding controlled at first by Pressure alone; next Pressure and Liquor Ferri Persulph. were tried without Success; then the Actual Cautery arrested the Bleeding; Recovery.* — S. W., private, Co. C, 35th O. Vols., was wounded at Chickamauga, September 20th, second day's battle. The ball struck him about six inches below the knee-joint, passed through the tibialis anticus and extensor longus digitorum muscles, and lodged in the tibia. But little hemorrhage followed the infliction of the wound. The patient was retained in the field hospital but two or three days, and was transferred to Nashville, where he arrived September 28th.

Most of the wounded had to be transferred from the battle-field in ambulances and wagons by a circuitous route, over very rough and almost impassable roads, a distance of nearly sixty miles, to Stevenson, Ala., and thence to Nashville by railroad, over one hundred miles further. Our supplies were somewhat deficient, and the enemy were very often interrupting our communications. These causes combined largely contributed to the sufferings of the sick and wounded, and rendered it impossible to cleanse and dress the wounds excepting at long intervals; the consequence was that *when the patients arrived at Nashville*, many of the wounds presented an unhealthy appearance, and in some cases, a tendency to gangrene. This was the condition of S. W.'s wound. After cleansing the patient's (S. W.'s) wound, water dressings were applied. The patient seemed to improve up to Oct. 5th, when hemorrhage suddenly supervened — the bleeding was supposed to be from the anterior tibial artery, and for the time being it was arrested by compression. Ordered, ℞ Tr. ferri chlorid. ʒ iij., quiniæ sulph. gr. xxiv., aq. dest. ʒ vj., M. Dose, tablespoonful every two hours.

[1] Vide pp. 52, 53, 73, 74 of this essay.

Under this treatment the patient improved, and the wound assumed a more healthy appearance, until October 11th, when hemorrhage again occurred. Compression again served to control the bleeding. About ten ounces of blood were lost by the second hemorrhage. Within twenty-four hours hemorrhage again came on; this time the persulph. ferri was used with compression, and sufficed to control, but did not wholly arrest the bleeding. After waiting two hours, the *actual cautery* was thoroughly applied to the bleeding part.

From this time onward the case did well, and a favorable prognosis was made; but ten days subsequently hemorrhage again occurred; styptics were tried in vain; the hemorrhage was alarming. The wound was again thoroughly *cauterized*, which sufficed to permanently arrest the bleeding. The wound subsequently healed up kindly and perfectly.

Dr. Clendenin's experience with actual cautery.

In secondary hemorrhage from sloughing and gangrenous wounds, "I have," says Dr. Clendenin, "succeeded very well in arresting the bleeding by means of the *actual cautery*. To be effectual, the cautery must be applied in the wound with an unsparing hand, so as to destroy the slough, and to completely seal up the orifice in the bleeding vessel."

The following case was also contributed by Dr. Clendenin: —

Case LXXII. *Gunshot Wound of Right Buttock penetrating Pelvic Cavity; Secondary Hemorrhage commencing on Twelfth Day; Pressure and Styptics tried without Success; Actual Cautery also unsuccessful.* — A member of the 6th Regiment, New Hampshire Vols., was wounded in the hip during the second battle of Bull Run. The ball entered the buttock on the right side, near its centre, passing through the glutæi muscles, perforating the os innominata, and lodging within the pelvic cavity.

The patient was a young man of sandy complexion, apparently in good health at the time the wound was received. On the fifth day the man was transferred to Washington. When admitted to hospital the patient seemed to be in good condition, and the wound looked healthy. The case progressed well without presenting any untoward symptoms until the morning of the twelfth day, when blood began to ooze from the wound. at first slowly, but during the day it became more copious. Styptics, compression, etc., were used persistently, but without much success; hemorrhage supervened from time to time until the patient's life was seriously endangered thereby. The wound was enlarged for the purpose of ligating the vessel; but failing to find the bleeding vessel, the surgeon applied the actual cautery, by which the hemorrhage was arrested.

On the succeeding day profuse bleeding again supervened; the actual

cautery was again applied very thoroughly, but without effect, and the wound was subsequently twice cauterized, yet the hemorrhage continued. The patient died on the sixteenth day, from the loss of blood.

Post-mortem Examination. — The bullet had passed through the ilium, and was found lying upon the floor of the pelvis. It had wounded in its course the deep superior branch of the gluteal artery (external to the ilium), and, within the pelvis, the posterior trunk of the internal iliac artery. The first blood had undoubtedly come from the deep superior branch of the gluteal, which was arrested by the cautery. The subsequent bleeding was from the posterior trunk of the internal iliac, and, consequently, it was beyond the reach of the cautery.

Comments. — In the last case it is probable that the actual cautery failed to arrest the flow of blood because it could not be applied to the bleeding orifice, which was located within the cavity of the pelvis. The last two cases show conclusively that the actual cautery is a more reliable agent for procuring the arrest of secondary hemorrhage, than pressure and the persulphate of iron, or any other astringent substance, whether applied singly or in combination, since it succeeded in stopping the bleeding after they had failed. Moreover, the actual cautery is well adapted to an important class of cases, in the treatment of which the surgeon often experiences much embarrassment, from the fact that the vessel lies in the midst of gangrenous or sloughing tissues, and its coats are so much softened that they will not hold a ligature. In such cases the surgeon may arrest the hemorrhage either by tying the main arterial trunk at some point between the wound and the heart, or by applying the actual cautery freely in the wound itself. The latter proceeding seems quite as likely to prove successful as the other, and doubtless should be preferred in the treatment of many cases of this sort.

More reliable than pressure and astringents.

In sloughing and gangrenous parts.

4. *With regard to the Employment of Torsion* for the purpose of arresting hemorrhage from wounded arteries, it does not appear that the experience of the late war has made any addition to the stock of our knowledge on the subject. It must be considered as an expedient of minor importance for the suppression of bleeding from injured arteries.

Torsion.

5. *Of Amputation as an Operative Procedure which may sometimes be required in Consequence of Secondary Hemorrhage from Wounded Arteries.* — Amputation was one of the leading operative resources employed by the ancients for

Amputation by the ancients for hemorrhage.

the relief of hemorrhage from wounds involving the principal arteries of the extremities; and we are sometimes compelled to practice it even at the present day in order to save our patients from death by hemorrhage and for other causes. Thus, in some cases of parenchymatous hemorrhage, all other means of arresting the flow of blood having failed, we are forced to amputate the member as a surgical proceeding of last resort. Again, it will be remembered that in Cases II. and III. the posterior tibial artery had been bruised by a gunshot projectile, which also shattered and comminuted the bones entering into the formation of the ankle-joint, and that when secondary hemorrhage was produced by the separation of the sloughing coats of the artery, amputation was performed, because it was thought to afford the best opportunity for the patient's recovery. In Case LXI. the elbow-joint was badly fractured by a musket-ball. Afterwards, the brachial artery was opened by the sloughing process, and profuse secondary hemorrhage occurred. The arm was amputated, with a good result.[1]

In what cases still employed.

6. *Of the Employment of the Ligature as a Means of arresting the Flow of Blood from a Wounded Artery.* — The following illustrative case was contributed by Dr. W. Clendenin, late Surgeon U. S. Vols.

Dr. Clendenin's contribution.

Case LXXIII. *Gunshot Wound of Upper Part of Neck; Bullet passed through from Side to Side; Secondary Hemorrhage on Fourteenth Day; it was treated by Pressure; it recurred Several Times, and finally terminated in Death; Interesting Reflections; Interesting Statements with Regard to Other Cases of Secondary Hemorrhage, wherein Pressure and the Persulphate of Iron had failed, which were finally saved by Ligation.* — Charles Raymond, private, 120th Pa. Vols., was wounded in the neck at Chancellorsville. The ball passed through the posterior border of the sterno-cleido mastoid muscle, about two inches below its insertion, and made its exit just anterior to the muscle of the same name on the opposite side of the neck, opposite the upper border of the thyroid cartilage. For a moment or two the bleeding was profuse, and was attended with great nervous prostration, which culminated in syncope.

The bleeding did not recur after reaction was established. There was no intermediary hemorrhage. On the third day the patient was transferred to hospital at Washington. He swallowed with difficulty, but there was no other evidence of the œsophagus having sustained any injury; respiration was not interfered with in any way. There were no untoward symptoms manifested, and for a week the patient ate and slept well, and was evidently gaining strength under the influence of iron

[1] See also Cases LXII. and LXVI.

and quinine, with a nutritious diet. On the fourteenth day, while he was quietly sitting by the window, blood suddenly gushed from the wound of entrance. The attending surgeon, being in the ward at the time, succeeded in promptly arresting the bleeding, by making compression upon the carotid. Eighteen hours afterwards the hemorrhage again supervened. It could not positively be determined what artery was wounded. The facial artery could be felt pulsating upon the ramus of the inferior maxilla, and the temporal in front of the external meatus of the ear. Compression was again made with success, and the case again left to nature. An intelligent nurse was put in charge of the case for the night.

The prognosis of the case was fairly stated to the patient and his father (who had just arrived at the hospital), and ligature of the bleeding vessel urged as the only reliable means of arresting the bleeding permanently; but both the patient himself and his father opposed the operation, and insisted that nothing should be done unless the bleeding again occurred. The following morning, on my return to the hospital, I found my patient dead; hemorrhage had supervened during the night, which the nurse was unable to control; and before the attending surgeon could reach the bedside of the patient, he had lost so much blood that death ensued within ten minutes thereafter. Here, then, upon the table in the dissecting-room, was presented to me, [says Dr. Clendenin,] a most profound and impressive essay upon the treatment of secondary hemorrhage. I then resolved never to allow one hour to pass by after the *second* bleeding, in cases of secondary hemorrhage, without applying a ligature upon the bleeding vessel, if possible to do so.

According to my own experience, [observes Dr. Clendenin,] *the ligature is the only* reliable method of treating secondary hemorrhage. A ligature should be put upon the vessel *both above and below* the source of the hemorrhage. In three cases of secondary hemorrhage, following wounds of the palmar arch — two cases of the left and one of the right hand — I tried compression upon the radial and ulnar arteries, together with the application of persulphate of iron to the wound; yet the bleeding recurred from time to time for from four to six days, and was finally permanently arrested by ligatures.

The ligature the most reliable.

In eight cases of secondary hemorrhage from the brachial artery (following gunshot wounds of the arm), I tried compression most faithfully, [Dr. Clendenin remarks,] but in every case nothing more was effected than the temporary arrest of the flow of blood; and after subjecting the patients to the torture of compression for many hours, the necessity for deligation became absolute, and the command, though reluctantly obeyed, was followed by success in each case.

Eight instances in which compression failed.

Comments. — The foregoing case again illustrates the inefficiency

of pressure when employed as a means of arresting secondary hemorrhage from an important artery.

It also affords an illustration of the fact that Guthrie's dictum to the surgeon, whereby he is directed not to tie a wounded artery, unless it bleed at the time, is far too broad and undiscriminating. If the wounded vessel in this case had been properly secured by ligature directly after the occurrence of the second hemorrhage, as suggested by Dr. Clendenin, this patient's life might have been saved. But by adopting the policy of procrastination, he was allowed to bleed to death. In the case of John Williams, No. XXIX., the brachial artery was partially divided with the point of a sabre, near its commencement. It was promptly secured by two ligatures, one of which was applied on each side of the orifice, when the patient was brought to the hospital, although it did not bleed at the time. I maintain that this procedure was eminently proper in this case; for it is almost certain that, sooner or later, the hemorrhage would have started afresh, and, if it occurred in the night-time, so much blood might be lost, before the wounded vessel could be secured by ligature, as to place the patient's life in great peril, or even to utterly destroy it. Instances of similar import might be indefinitely multiplied, if it were necessary so to do.

Guthrie's direction.

Fatal consequences of this policy.

Good results of a different policy.

The ligature is employed for the arrest of arterial hemorrhage in three different situations, as already stated: 1st. It is applied in the wound itself, to the injured vessel on each side of the lesion in its walls, on the old plan; 2d. It is applied to the proximal portion of the artery before it reaches the wound, but near to it, on the plan of Anel; and 3d. It is applied to the main arterial trunk at a point remote from the wound, on the plan of Hunter.

Where to apply ligature.

The following case was contributed by Dr. C. A. Leale, late Acting Assistant Surgeon U. S. Army.

A case contributed by Dr. Leale.

Case LXXIV. *Gunshot Wound of Leg, fracturing Fibula and cutting across Posterior Tibial Artery; Secondary Hemorrhage commencing on Tenth Day; Pressure and Astringents failed to arrest it; Old Operation performed; Hemorrhage arrested, but Death ultimately occurred from Pyæmia.* — William H. Jones, private, Co. E, 65th N. Y. Vols., aged 26; wounded at Fort Fisher, on the 25th of March, 1865, by a *minie ball, which passed through the middle third of his leg, fracturing fibula and cutting across the posterior tibial artery.*

He was admitted to Armory Square Hospital, March 28th. Two

pieces of the fibula were removed at Field Hospital; there was considerable hemorrhage at time of injury; secondary hemorrhage took place April 4th, which was checked by liq. ferri persulph., and compression of popliteal artery. The hemorrhage recurred about twenty-four hours after, on the 5th; lost about four ounces of blood on 4th, and same quantity to day. Styptics will not check it.

He was placed under an anæsthetic, and the wound was enlarged by cutting between the gastrocnemius and soleus muscles; the artery was ligated at both its distal and proximal extremities, but only after about forty minutes' labor and considerable loss of blood — about eight ounces. When he came out from under the anæsthetic he was very feeble; gave immediately brandy and champagne every half hour, with beef-tea, q. s.; had several chills during the day.

April 6. — Wound perfectly dry, not the slightest suppuration noticed; stimulants and beef-tea.

April 11. — Chills have continued; wounds have commenced to suppurate; extreme nausea; he is very anæmic. Stimulants and beef-tea, with an occasional anodyne, were prescribed.

April 17. — He was transferred to Ward G, where he died on the 19th (I think).

Comments. — This case affords us another example in which pressure and styptics failed to control the flow of blood from an important artery, which had been severed by a gunshot projectile.

It also shows the great superiority of the ligature as a hæmostatic agent over compression and the persulphate of iron. After the bleeding vessel was tied, the hemorrhage did not return.

In this case the ligation was practiced in the original wound, and two ligatures were employed. One of them was applied to the proximal, and the other to the distal end of the divided artery. The distal ligature was applied for the purpose of preventing recurrent hemorrhage, or bleeding from the mouth of the distal portion of the vessel.

This operation is, in most cases of hemorrhage from wounded, ulcerated, and sloughing arteries, to be preferred to either of the other methods of ligation, because it is believed to be more successful in arresting the bleeding permanently.

Pyæmia in connection with wounds of arteries.

This patient died of pyæmia; and this circumstance calls our attention to the fact that the purulent infection not unfrequently occurs in connection with wounds and injuries of arteries. Of the cases of secondary hemorrhage narrated in these pages, *seven* terminated in death from pyæmia; and, so far as the development of that affection is concerned, the wounds and injuries of blood-vessels must be considered as the next most prolific cause after the traumatic lesions of the osseous tissue.

In the next case secondary hemorrhage occurred from a wound of the tongue. It was treated successfully by the application of a ligature after the method of Anel. The account of it has been contributed by Dr. W. Clendenin, late Surg. U. S. Vols.

Case contributed by Dr. Clendenin.

Case LXXV. *Gunshot Wound of Cheek, Tongue, and Throat; Secondary Hemorrhage on Seventh Day from Mouth; Astringents failed to arrest it; Ligation of Lingual Artery, which arrested the Bleeding, and it did not return; Recovery.* — —— McIntire, a private of —— Mass. Vols., was wounded in the neck at the Battle of Mission Ridge. The ball passed through the left cheek, carrying away the first and second molar teeth of the corresponding side, thence through the under surface of the tongue obliquely from above downwards and forwards, and emerging immediately beneath the horizontal ramus of *the lower jaw* external to the point of insertion of the digastricus muscle. There was but slight hemorrhage. The loose spiculæ of bone and the teeth were removed with the forceps, and the external wound dressed with lint wet with cold water. On the seventh day hemorrhage occurred; the blood flowed from the mouth entirely. Styptics were tried, but, proving useless, I proceeded to ligate the lingual artery at the point where that vessel passes into the submaxillary triangle, and thence upward behind the Hyo-glossus muscle.

The ligature was successfully applied, and the hemorrhage arrested. The bleeding did not recur. The patient made a good and perfect recovery.

In the following case secondary hemorrhage occurred in a thigh-stump, on the twenty-third day after amputation. It was very profuse, and the patient lost two and one half pounds of blood in one minute. It was treated successfully by the application of a ligature to the femoral artery on the plan of Anel. Its history has been contributed by Dr. A. W. Heise, late Surg. 100th Ill. Vols.

Case contributed by Dr. Heise.

Case LXXVI. *Gunshot Fracture of Thigh involving Knee-joint; Amputation; Secondary Hemorrhage from Stump on Twenty-third Day afterwards; ligated Femoral Artery in Scarpa's Space, which arrested the Bleeding permanently; Recovery.* — Capt. Hezekiah Gardiner, 100th Ill. Vols., wounded at Mission Ridge, Nov. 25th, 1863. A musket-ball had entered two inches above right knee-joint, and escaped at the popliteal space, fracturing the femur to its middle third, and into the knee-joint. Passing my finger through the opening from which the ball had escaped, the popliteal artery could be distinctly felt denuded of its sheath. A consultation was held with Surgeons Glick and Phelps, U. S. Vols., and decided to amputate, which was done the following morning, in the middle third of femur, by the anterior and posterior flap-method.

November 27. — Progressing very favorably; two thirds of stump healed by first intention; is cheerful, sleeps well, and has a good appetite.

Everything went on exceedingly well up to December 19th, when all at once fearful hemorrhage occurred. The patient lost, in one minute, two and a half pounds of blood. The femoral artery was ligated in Scarpa's triangle. A nourishing diet, with beer, milk-punch, and an opiate at night were allowed.

January 18. — Ligature was removed this morning; patient doing very well; is able to sit up; expects to go home on a leave in eight or ten days; stump healed.

Comments. — While the old operation, which consists of securing the bleeding artery by two ligatures applied in the wound, one on the proximal and the other on the distal side of the orifice in the arterial tunics, is, in most cases of secondary hemorrhage, to be preferred to any other form of ligation, still the tying of the injured vessel by the method of Anel may sometimes be employed with advantage to the patient and with credit to the surgeon. For example, in a case where, from any cause, a ligature cannot be applied to the artery at the place where it has been wounded, the next best thing that can be done is to tie it, on the proximal side, as close to the wound as possible, which is, to all intents and purposes, the operation of Anel. Thus, in Case LXXV., a ligature could not be applied to the lingual artery where it was wounded in the tongue; but the hemorrhage was permanently arrested by tying the lingual artery at the place of election, and the patient made a good recovery.

Old operation preferred in secondary hemorrhage.

Plan of Anel.

Again, in cases of secondary hemorrhage occurring in arm and thigh stumps after amputation, the bleeding artery may oftentimes be ligated on the plan of Anel, with marked advantage, especially if the tissues at the end of the stump are sloughing, and the coats of the vessel are too soft to hold a ligature in that situation.

Dr. David P. Smith's contribution.

The next four cases have been contributed by Dr. David P. Smith, late Surg. U. S. Vols., in charge of Fairfax Seminary U. S. Army General Hospital. They are cases of secondary hemorrhage in which ligatures were applied between the wound and the heart, and were followed by success.

Four cases successfully treated.

First. — —— was admitted into Fairfax Seminary Hospital, in October, 1862, with gunshot wound perforating upper third right forearm, passing anterior to the bones. Sometime after admission, profuse hemorrhage occurring, the usual incisions were made, both the ulnar and

interosseous arteries found, and repeated attempts made to place ligatures upon them. The molecular disintegration of the tissues was so great that they would not hold, and consequently the brachial was tied in the bend of the elbow. Not a bad symptom followed, and he was soon sent home with wound entirely cicatrized, suffering only from contraction of flexor muscles resulting from loss of substance.

Brachial artery tied on Hunter's plan.

SECOND.— ——Klinghard was admitted into Fairfax Seminary Hospital in May, 1864, with gunshot fracture of ascending ramus of right lower jaw. Upon insertion of the finger into orifice of entrance just below zygoma, the ball was felt lying behind the ramus, and was easily removed. A large fragment of bone loose in the tissues was then seized and drawn out by the forceps, when a tremendous gush of blood took place. The twisted suture was used to close the external wound, and the common carotid immediately ligated. No further hemorrhage occurred. The operator and writer of this was soon afterwards prostrated by a dissection-wound, and, being relieved from duty, lost sight of the case. On his return to hospital duty in December, Klinghard was found in good health, suffering only from inability to open his jaws sufficiently to chew solid food. He was soon afterwards discharged from the service.

Common carotid tied on Hunter's plan.

THIRD.— —— Salmon, —— ——, was admitted into Fairfax Seminary Hospital, in April, 1865, with gunshot fracture of right lower jaw, at the junction of the horizontal and ascending rami; bullet entering at corner of the mouth, and passing out directly over the carotid artery. Shortly after admission the injured side became greatly infiltrated with blood, and external hemorrhage took place to the amount of twelve or sixteen ounces. The common carotid artery was at once tied. Hemorrhage ceased for twelve hours, and the engorgement of the side of the face diminished to a great extent. At the expiration of that time a small hemorrhage occurred, but was readily checked by the persulphate of iron. This occurred several times to a small extent. Brandy and beef-tea was assiduously given, and the man slowly gained until the wound closed without further operative procedure.

Common carotid tied on Hunter's plan.

FOURTH.— —— —— was admitted into Fairfax Seminary Hospital in May, 1865, having already been subjected to a partial exsection of left fibula for gunshot injury. About ten days from time of operation profuse hemorrhage occurred, flooding the bed. The superficial femoral was immediately ligated in Scarpa's triangle. No further hemorrhage occurred, and wound rapidly cicatrized.

Femoral tied on Hunter's plan.

Dr. Smith observes that the above mentioned cases are very significant. The two cases of ligature of the carotid were the only

ones that occurred to (him) and were both successful. In one instance of ligature of brachial at bend of elbow, upon the person of a major, on board of the hospital transport Atlantic, for profuse hemorrhage, resulting from gunshot flesh-wound of fore arm, the result could not be ascertained, and consequently it is not counted.

Enough cases of a similar character, says Dr. Smith, have occurred to warrant us in advocating the procedure whenever the wound is in a decidedly unhealthy condition. Mr. Guthrie's rule to tie every artery at the "bursten point" cannot always be followed, on account of the impossibility of reaching a sound portion of the artery through the wound.

Guthrie's rule cannot always be followed.

In the next case secondary hemorrhage followed a gunshot wound involving the face and neck. It was profuse, and the patient lost a large quantity of blood before surgical aid could be procured. The trunk of the common carotid artery was tied on the plan of Hunter, which restrained the hemorrhage, but the patient died comatose in about three hours after the operation. Its history was contributed by Dr. W. Clendenin, late Surg. U. S. Vols.

Case by Dr. Clendenin.

Case LXXVII. *Gunshot Wound of Mouth and Neck; Secondary Hemorrhage on Eighteenth Day; Ligature of Common Carotid Artery; Death Three Hours afterwards by Coma.* — J. R., of the 10th Ohio Vols., wounded at the battle of Stone River, Dec. 31st, 1862. The ball passed through the mouth under the tongue, and made its exit in the neck, posterior to the sterno-cleido mastoideus muscle, about two inches below the mastoid process on the right side. The wound did well until the night of the 17th of January, when hemorrhage suddenly supervened. The patient was alone at the time, and lost a large quantity of blood before medical aid could be procured; the patient was by permission at a private residence. Compression upon the right carotid artery controlled the bleeding. The surgeon in charge of the case, instructed the attendants how to make compression, which was kept up until daylight. Compression was discontinued without the recurrence of the hemorrhage; the patient was then transferred to a hospital. The patient remained quite comfortable during the day, but the following morning the hemorrhage again supervened, and was again arrested by compression. Four hours after, the hemorrhage again supervened, and the surgeon at once proceeded to ligate the artery, which he did after a protracted search, occupying fully one hour.

The patient became comatose within a few moments after the ligature was applied, and death ensued in about three hours.

The brother of the deceased immediately obtained possession of the body, and a post-mortem examination could not be made.

In this case the operation was very protracted; but of this it must be said that the neck was so much swollen as to almost entirely obliterate the landmarks. But the chief cause of delay was the difficulty the surgeon experienced in detecting the situation of the vessel by its pulsation, after its neighborhood had been reached. The patient was very feeble from loss of blood, the circulation was so very weak that the finger, being placed firmly upon the artery, was unable to appreciate any pulsation, for the same reason that the pulse at the wrist cannot be felt when it is excessively feeble, if the artery be firmly pressed back against the bone. Let him hold his finger lightly upon the vessel and he will then feel its feeble thrill against his finger. In this case, too large an opening was made in the sheath, and the vein bulged up over the artery, and embarrassed the operation very much.

Comments. — The fatal result in this case, which was attended with the production of cerebral symptoms, whose development began a few minutes after the ligature was applied, reminds the author that of the *eleven* cases related in the pages of this essay, wherein the common carotid artery was tied on the plan of Hunter, for the purpose of arresting hemorrhage (primary in one, secondary in ten instances) from the internal carotid artery, or from some branch or branches of the external carotid artery, *seven* died, but *three* recovered, and in one case the result is not stated. In the fatal cases death was produced by the following causes: inflammation of the brain in two instances, softening of the brain in one instance, abscess of the brain in one instance, coma in one instance, exhaustion resulting from loss of blood occasioned by a repetition of hemorrhages from a wounded occipital artery in one instance, and exhaustion produced by loss of blood which occurred prior to the operation in one instance. In *five* of the *seven* fatal cases, death was produced by either inflammation, or softening, or abscess, of the brain, or by coma; that is, by some affection of the brain.[1] In the remaining two cases, it was occasioned by the loss of blood. The ratio of mortality attending the ligation of the common carotid artery for the suppression of traumatic hemorrhage is, according to this exhibit, very great, being no less than 63.6 per cent., on the supposition that the case, the result of which is not stated, terminated in recovery. The question, therefore, naturally arises

Cerebral mischief from tying common carotid.

Fatality of operation very great.

[1] Dr. Norris' valuable and well-known paper on ligation of the carotid artery teaches substantially the same important lesson. *American Journal Medical Sciences*, 1845, vol. x.

Thus, of thirty-two deaths following ligature of the common carotid artery, eighteen, or more than half, were due to cerebral disease. See also Erichsen's *Science and Art of Surgery*, pp. 521, 522.

whether some operative procedure other than ligation of the common carotid artery might not be employed for the relief of this class of cases with more successful results. In the opinion of the author, this question should be answered in the affirmative. In the case of ligation of the right common carotid artery, wherein recovery took place,[1] the bleeding was not permanently arrested until the left *external* carotid was also tied. The lingual artery being the source of the hemorrhage, why would it not have been preferable to tie that artery at the place of election, as was done, with a good result, by Clendenin in Case No. LXXV.? The lingual artery could have been tied on both sides if necessary, without detriment to the brain. In cases of consecutive hemorrhage occurring in the face and upper part of the neck, where it is uncertain what branch or branches of the external carotid artery are wounded, ligation of the external carotid itself might be practiced on both sides, if necessary, without inducing inflammation or other lesion of the brain. This operation, too, would be more likely to restrain the bleeding permanently, in such cases, than the ligation of the common trunk of the carotid vessels; for it happened in three of the eleven cases, wherein the last-mentioned operation was performed, that the hemorrhage returned.[2] The case of incised wound of the occipital artery which proved fatal by a repetition of the hemorrhages, should have been treated, not by ligating the common carotid artery, but by tying the injured vessel in the wound, or, in case that could not be done, by tying the occipital artery on the plan of Anel, on both sides if necessary to restrain the bleeding, or, in case that operation could not be performed, by ligating the *external* carotid artery. By pursuing such a course in the surgical treatment of this class of hemorrhages, the bleeding would be controlled with greater certainty, the brain would be much less likely to sustain injury, and the patient would be more apt to recover, than he is when treated by ligation of the common carotid artery.

When not to tie the common carotid.

CASE LXXVIII. *Gunshot Wound of Neck followed by Secondary Hemorrhage; Ligation of Common Carotid Artery*; it was contributed by Dr. B. Howard, late Assistant Surg., U. S. Army. — Private Daniel Zichler, Co. A, 9th Mass., 2d Brigade, 1st Division, 5th Corps, was struck by a ball just anterior to his left ear, the ball passing backwards, downwards, and outwards.

Dr. B. Howard's case.

Several days afterwards (May 17th), profuse secondary hemorrhage

[1] Vide Case No. LV.

[2] Vide Cases Nos. XXX. and LXIX.

occurred from the wound, which I immediately arrested by ligating the common carotid, at the anterior border of S. cleid. mastoideus.

The next day, May 18, pulse was ninety-six, and patient felt comfortable.

May 19. — Pulse eighty-four and equal.

May 20. — Pulse one hundred and equal.

May 21. — Pulse eighty and equal. Patient complained of burning sensation of right side of head.

Dr. Smith, of Tappan, N. Y., who remained in attendance upon him at Fredericksburg, reported him very comfortable on the eighth day after operation.

The following case, in which the external iliac artery was tied for secondary hemorrhage, has been contributed by Dr. C. A. Leale, late Acting Assistant Surgeon, U. S. Army. Dr. Leale's case.

Case LXXIX. *Gunshot Wound of Thigh; Secondary Hemorrhage; Ligation of External Iliac Artery; Bleeding recurred, but it was controlled by Pressure; Pyæmia; Result not stated.* — James R. Spaulding, 112th N. Y., wounded at Fort Fisher, January 15th, 1865, through fleshy portion of left thigh. In the last of January the wound began to ulcerate, and then to bleed. He was then able to sit up in a chair.

April 2, 1865. — Dr. S. M. Horton, U. S. Army, tied the external iliac artery.

Secondary hemorrhage occurred some time afterwards, but it was controlled by pressure.

Has now extensive suppuration, diarrhœa, sweet breath, chills, sweats, bed sores, appetite poor, no cough, skin clear, pulse rapid, tongue pale and polished. Result not stated, but it is supposed to have been fatal.

Case LXXX. *Ligature of Common Iliac Artery for Secondary Hemorrhage from Gunshot Wound of Thigh, near Pelvis; Recovery from Operation, but Death Three Months afterward from Typhoid Fever.* — Prof. Brainard has reported the following case in which he performed this operation: —

April 9, 1863, called to visit Colonel Scott, 19th Illinois Vols., who was wounded at the battle of Stone River. A musket-ball had passed from before backwards through the thigh, entering below the pelvis and at the outside of the femoral artery, grazing the inside of the femur, and coming out of the buttock.

At the time of the accident there was hemorrhage, which was controlled, as was supposed, by pressure on the femoral artery. The compression was continued about three weeks, during which time no hemorrhage occurred. The wound suppurated, and some small scales of bone came out of each orifice of the wound.

He was removed to his home in Chicago, and did well, although the

wound remained open behind, until about the 5th of April, three weeks after the accident, when a small tumor formed in front, which was opened. A day or two afterwards, hemorrhage occurred from both openings. It was for this that my advice was asked. On the night of the 9th, at eleven o'clock, copious hemorrhage again occurred, which was controlled in a measure, but continued at intervals during the night.

April 10. — Saw him at ten o'clock, and applied the compressor over the femoral artery. This seemed to arrest the bleeding, but in about two hours it returned.

The bleeding had been so great as to threaten life, and I determined to tie the external iliac artery, not doubting from the history of the case that the hemorrhage came from branches of the profunda femoris, close to its origin.

With the aid of Prof. Freer and the Drs. Hurlburt, the ligature was placed upon the external iliac artery in the usual manner, as that described by Lisfranc; but on changing the position of the patient to remove the soiled bed-clothing, the bleeding returned as freely as ever. On a rëexamination, the ligature was found to control the external iliac, and it was evident that the ischiatic artery was the one now giving blood. The danger was urgent, and I enlarged the wound of operation upward and outward, and placed a ligature on the common iliac artery. The anterior wound in the thigh was then enlarged, and a great quantity of coagula removed from it by the finger. No bleeding; patient under chloroform during the operation. Warm applications to the member: brandy and broth ordered.

April 11, A. M. — Limb cool, but not cold; has been troubled with nausea and attempts to vomit, which gave pain in the wound; pulse one hundred, condition good. Ordered an enema and a solution of soda bicarb., with gum arabic for the vomiting. Broth continued.

April 12. — Has considerable pain and tenderness in the region of the left kidney; pulse one hundred and twenty; slept well during the night with two doses of acetum opii; wounds commencing to suppurate.

April 13. — Pulse one hundred; tenderness in left side diminished; takes broth with wine; slept well.

April 20. — Cut of operation suppurates freely. Allowed beef-broth and wine, with opiate at night.

April 24. — Ligature on the external iliac artery came away.

May 1. — Ligature on common iliac came away. Patient doing well.

May 12. — Wound of operation healed.

From this time he remained in good health until the early part of July, although the wound continued to suppurate, and some small pieces of bone were discharged at the posterior orifice.

At this time he was attacked by a copious watery diarrhœa, followed by typhoid fever, of which he died July 8, three months after the operation.[1]

[1] Vide *American Journal Medical Sciences*, April, 1864, pp. 565, 566.

The next two illustrative cases have been contributed by Dr. C. A. Leale, late Acting Assistant Surgeon, U. S. Army.

Two cases contributed by Dr. Leale.

Case LXXXI. *Gunshot Wound of Thigh (Lower Third) involving Femoral Artery; Artery Tied in Tendinous Canal of the Adductor Magnus; Secondary Hemorrhage; Tied Femoral Artery then at Apex of Scarpa's Triangle; Death some Time afterwards (Two Months).* — Joseph O'Keefe, Major 2d N. Y. Vols., aged 24, wounded at Five Forks, Va., April 1, 1865, by a canister-ball in the postero-inner part of the right thigh, at its lower third, near the base of the popliteal space (flesh wound). The femoral artery was injured, considerable hemorrhage followed, the vessel was ligated within the adductor magnus muscle, the ligature sloughed off, and the artery was again ligated at apex of Scarpa's triangle, at City Point.

April 29. — Admitted to the Armory Square U. S. Army General Hospital. He was then very anæmic; the limb was œdematous from foot to Poupart's ligament; was carried to the hospital from the transport on a stretcher, under the immediate charge of Assistant Surgeon Parry. He had considerable pain, which seemed to be produced mainly by the tension of the integuments that resulted from the œdematous swelling of the limb. After consultation, I bandaged the limb from foot to seat of injury. Prescribed champagne, one bottle daily, anodynes, and beef-tea.

May 2. — Has rested very comfortably; appetite good; transferred to R. C. Hospital, where he died about one month afterwards.

The author supposes that the œdema of the limb presented in the foregoing case, was due to the occlusion of the femoral vein, either in consequence of original injury of the vein itself, or of thrombosis.

Case LXXXII. *Secondary Hemorrhage from Stump after Amputation at Shoulder-joint; Bleedings very Profuse and repeated; arrested by Pressure on the Subclavian; Recovery.* — J. G. Twerk, 1st Lieutenant 3d N. J. Battery, age 35, wounded at Fort Haskell by a conical ball, in *left arm, upper third;* admitted to Armory Square Hospital, 24th April, 1865; arm had been *amputated* while at City Point, at *shoulder-joint.*

While at City Point Hospital, also, had hemorrhage several times (twice) from the axillary artery in stump; it was checked each time by digital pressure and compresses (after the patient had lost an immense quantity of blood), applied on the subclavian artery.

When admitted to Armory Square Hospital, he was very anæmic; had considerable pain, the seat of the greater part of which was above the clavicle, where a large abscess had formed in consequence of the pressure. This I explored with a grooved needle; found pus, which I evacuated by a free incision; discharged eight ounces of laudable pus.

Gave stimulants, morphia, and beef-tea.

July. — The patient has had no unfavorable symptoms since last note. Has continued to improve; the stump has entirely closed; there is a slight superabundance of flap. He is in good condition, having become quite plethoric; no pain and excellent spirits.

Comments. — The author, however, thinks that it would have been preferable, in the case just related, to tie the subclavian artery when the first hemorrhage occurred (provided, of course, that the bleeding vessel could not be secured with a ligature in the stump), instead of relying upon compression of the subclavian artery to restrain the bleeding; for with such treatment it is probable that the second hemorrhage would have been prevented, and the patient would have made a safer and more speedy recovery.

Ligation of subclavian would have been preferable.

We may here remark that secondary hemorrhage occurring in a stump admits of being treated on principles somewhat different from those which should guide the surgeon in cases of secondary hemorrhage occurring in the continuity of a limb, because in stumps there is no risk of bleeding from the distal orifice, and but small risk of the occurrence of consecutive gangrene when the main artery is tied on the plan of Anel or Hunter, for the purpose of suppressing secondary hemorrhage. Thus, the principal objections to the employment of the ligature on the plan of Anel or Hunter for arresting hemorrhage when it occurs from wounds in the continuity of the extremities, do not hold good in cases of secondary bleeding, when it occurs in the stumps of amputated limbs.

Secondary hemorrhage in stumps.

CONCLUSIONS CONCERNING THE EMPLOYMENT OF THE LIGATURE FOR RESTRAINING HEMORRHAGE.

1st. The ligature is the most reliable of all the means we possess for restraining hemorrhage.[1]

2d. The ligature should be applied to the wounded vessel at the place of injury for such purpose, whenever the operation is practicable.

3d. When an important artery is wounded in its continuity, two ligatures should always be applied to the vessel, one on each side of the bleeding orifice in its walls, or one on each end if it has been completely divided; for if a proximal ligature only is employed, it happens not unfrequently that hemorrhage from the distal orifice or end of the artery occurs soon after the collateral circulation is established.

[1] See pp. 221 to 228 of this essay.

4th. The operation of tying the wounded vessel should not be unnecessarily delayed, for such procrastination has not unfrequently produced disastrous consequences.[1]

5th. Guthrie's direction that when arterial hemorrhage occurs, the wound should not be dilated and the vessel tied, unless bleeding exists at the time, is far too broad and undiscriminating; for if the injured vessel has a large size, or is but partially divided, or the hemorrhage is only temporarily arrested by some foreign body, or by coagulated blood in the track of the wound outside the vessel, the observance of this rule may unnecessarily place the patient's life in great peril.

6th. When the course of the external wound is very oblique, and the spot where the artery is injured can be ascertained, it is not unfrequently advisable to cut directly down upon the vessel at the place of injury, instead of enlarging the original wound by incision.[2]

7th. When the wounded vessel is not accessible at the place of injury, for the purpose of tying it, as, for example, in some cases where the tongue is wounded, or some branch of the internal maxillary artery is injured by a penetrating wound of the face, or some branch of the internal iliac artery by a similar wound of the pelvis, the main trunk should be secured by ligature applied as near to the injured part as practicable.

8th. When it is not practicable to tie the wounded vessel at the place of injury, it is generally better to tie the main trunk on the plan of Anel than on the plan of Hunter; as, for example, when some branch of the lingual artery is wounded, it is preferable to tie that artery itself at the place of election, instead of the external carotid, and, when the internal maxillary is wounded, to tie the external carotid instead of the common carotid; and, indeed, when any branch of the external carotid is wounded in such a situation that it cannot be tied at the place of injury nor in its course, it is better to tie the external than the common carotid, for, by so doing, the consecutive lesions of the brain, which are very frequently produced by the latter operation, are entirely avoided.[3]

9th. Secondary hemorrhage occurring in the stumps of amputated limbs, not parenchymatous in character, should be treated, when profuse or dangerous, by opening the flaps and tying the

[1] See pp. 221, 222, of this essay.
[2] See Case of John Williams, No. XXIX.
[3] See pp. 228, 229, 230, also Dr. Prince's remarks on p. 149 of this essay.

bleeding orifice. When that operation is not practicable by reason of sloughing of the parts, or because the walls of the artery are too rotten to hold a ligature, or for other cause, the main trunk should be secured on the plan of Anel or Hunter. When the bleeding is slight, and probably does not proceed from the main artery, it should be treated with styptics, or compression, or both combined. The same directions are, in the main, applicable to the treatment of secondary hemorrhage from wounds in the continuity of the limbs.

10th. But secondary hemorrhage occurring in the palm of the hand, when the bleeding vessel cannot be secured in the wound itself, from the tumefaction or sloughing condition of the parts, or because the performance of the operation would require division of the annular ligament, or for other sufficient cause, the brachial artery should generally be tied on the plan of Hunter.

11th. When an important artery of the extremities has been wounded by a fragment of bone in a case of *simple* fracture, and an operation is necessary, it may be advisable to tie the main trunk on the plan of Hunter, as originally recommended by Dupuytren, rather than to amputate the member.[1] But, when the fracture is compound, it is generally preferable to tie the injured vessel in the wound, or to amputate, if the parts are so much bruised and torn that in all probability the vitality of the limb will not be maintained after the operation.

12th. The metallic ligature or suture generally appears to be preferable to the silken or linen article, because of its non-absorbent properties. Thus, it is not liable to become soaked with decomposing discharges; and thus it produces less irritation of the surrounding parts than the other kinds of ligature.

Why the metallic ligature is generally to be preferred.

7. *Of Acupressure as an Hæmostatic Agent.* — Dr. Otis states, in Circular No. 6, concerning acupressure: "The new hæmostatic process recommended by Professor Simpson, was adopted in a few cases, with favorable results."[2] The author, however, has no experience in the employment of this procedure, and no original cases have been furnished him.

Dr. Otis' remarks.

[1] See pp. 20, 21, 37, 40, 128, 131 of this essay.

[2] Circular No 6, p. 79.

CHAPTER TWELFTH.

ON PARENCHYMATOUS HEMORRHAGE.

This Variety of Hemorrhage was not described until a Recent Period. — Stromeyer's Remarks concerning it. — The Blood in this Form of Hemorrhage does not issue in Distinct Streams. — Parenchymatous Hemorrhage may occur during the *Primary*, the *Intermediary*, and the *Secondary* Period. — The Pathology differs in the Several Periods. — The Pathology explained for each of these Periods. — A Case related in which Profuse Parenchymatous Hemorrhage occurred during the *Primary* Period. — Secondary Amputation of the Thigh performed for Gunshot Injury of the Leg; Copious Parenchymatous Bleeding from Surface of Stump; it was arrested by covering the Raw Surface of the Stump with Lint soaked in Liquor Ferri Persulph.; Recovery: why Parenchymatous Hemorrhage occurred in this Case. — Another Instance of this Form of Hemorrhage occurring during the *Primary* Period referred to. — An Illustrative Case contributed by Dr, Clendenin. — Gunshot Wound of Right Knee-joint; Secondary Amputation of Thigh, followed by very Profuse Parenchymatous Hemorrhage from the Stump; Death; Autopsy; Femoral Vein occluded by Thrombus. This Case differs from the Preceding because the Femoral Vein was occluded. — A Case in which Parenchymatous Hemorrhage occurred during the *Intermediary* Period referred to. — An Illustrative Case related, in which this Form of Bleeding occurred during the *Secondary* Period. — Gunshot Wound of Right Thigh in its Middle Third; Bone apparently not injured; Bullet lodged; Parenchymatous Hemorrhage on Thirty-second and Thirty-third Days; Death, with Symptoms of Pyæmia; Autopsy; Femoral, External, and Common Iliac Veins filled up with Coagulated Blood (Thrombus), which, in Some Places, was undergoing Spontaneous Degeneration, or Puriform Liquefaction. A Remarkable Instance of Parenchymatous Hemorrhage occurring during the Secondary Period referred to. —The Bleeding proved Fatal. — It was produced by Thrombus. — Another Case referred to in which this Form of Hemorrhage occurred during the Secondary Period. — Two Cases belonging to the Same Category related. — Gunshot Fracture of Left Radius and Right Carpus; Parenchymatous Hemorrhage from Both Wounds on Twenty-third Day; Amputation; Death; Autopsy. — Parenchymatous Hemorrhage from a Stump Sixteen Days after Amputation; Cold, Astringents and Pressure failed to arrest it; Reamputation; Death from Pyæmia, Five Days after the Operation; Autopsy; Visceral Abscesses found in Lungs and Liver. — Summary of Five Cases in which Parenchymatous Hemorrhage occurred during the Secondary Period. — On Capillary Bleeding from Granulating Surfaces produced by Venereal Excitement and by Excesses in Drinking. — The *Scorbutic Diathesis* does not induce Parenchymatous Hemorrhage. — *Treatment.* — To what Cases the Persulphate or the Perchloride of Iron is Applicable, and how it should be applied. — Concerning the Use of Hot Water as a Hæmostatic Agent. — How the Bleeding should be treated when it results from Thrombosis. — How Capillary Hemorrhage should be treated when it is produced by Strong Nervous or Vascular Excitement.

THIS variety of hemorrhage has not received distinct and special notice from surgeons until a very recent period. No account of it whatever is given by Guthrie, Hennen, or any of the older writers on military surgery. We therefore infer that it did not attract their attention. Concerning it Stromeyer says: —

Stromeyer's remarks.

"The parenchymatous hemorrhages are, as I have found, and will elsewhere prove by facts, at once a symptom of the entrance of pus into the veins, and of stoppage of the larger veins by coagulation. The stagnation of blood thereby ensuing gives rise to hemorrhage from the capillary vessels lying free in the wound, and, on this account, the blood so lost has neither a decidedly venous nor arterial character. Nevertheless, I will not assert that parenchymatous hemorrhages — independent of stagnation in the veins, and similar to scorbutic bleedings, — are not met with from the surface of wounds."[1]

Blood does not issue in distinct streams.

In cases of parenchymatous hemorrhage the blood does not issue from the wounded, or granulating, or ulcerating surface, in distinct streams, but seems to be poured out therefrom by a process of general oozing through small openings. We therefore infer that it has its anatomical source in the capillary vessels, and that it is, in reality, a capillary hemorrhage. In such cases the blood flows in a steady stream. It does not possess the purple hue of venous, nor the bright-red color of arterial blood. It is, in general, not so dark as the former, nor so bright as the latter. It therefore usually has a distinct color of its own, which, conjoined with the flow of the escaping blood in a steady current, has caused us at least to suspect, in some cases where these phenomena were present, that the hemorrhage was parenchymatous in character, before the wounded surface was exposed to view, or otherwise submitted to examination.

May occur during primary, intermediary, and secondary periods.

Parenchymatous hemorrhage has been met with during the *primary*, the *intermediary*, and the *secondary* periods in the history of wounds; but the causes which produce it, and the pathological conditions upon which its occurrence depends, are, for the most part, widely different in each of these three periods, but more especially in the primary and in the secondary ones. Parenchymatous hemorrhage has been

Pathology in primary period.

encountered during the *primary period* in connection with amputation of the thigh, and other members, performed through tissues that have been previously inflamed, and in which the inflammatory process has not yet entirely subsided. The consequence is that the dilated capillary blood-vessels, which have been divided in the operation, being paralyzed by the inflammatory process, are unable to contract so as to completely close the openings that have been made in them, and thus the blood flows unobstructedly from their open mouths, until it is arrested either by

[1] Vide Stromeyer on *Gunshot Fractures*, p. 15, Am. ed., 1862.

surgical art, or by the occurrence of syncope, or until death takes place.

Parenchymatous hemorrhage has been met with during the *intermediary period* in cases of amputation wherein the mouths of the dilated capillary blood-vessels were but feebly and imperfectly closed, so that when reaction, with the vascular excitement attending it, came on, these barriers against hemorrhage gave way, and the blood was poured out through the open mouths of the capillaries into the interior of the stump. In such cases, more or less parenchymatous bleeding had, for the most part, also occurred immediately after the performance of the operation, and, occasionally, the capillary oozing has continued in a minor degree, until the advent of the intermediary period, when the flow of blood becomes more copious for the reasons stated above. Pathology in intermediary period.

When parenchymatous hemorrhage occurs during the *secondary period*, it is generally associated with the symptoms of pyæmia, or, at least, with the pyæmoid phenomena, and is produced by the obstruction of the veins which proceed from the affected part toward the heart, with coagulated blood (*thrombus*), as was pointed out by Stromeyer. The condition of affairs, so far as the circulation of the blood is concerned, in a wounded limb, the principal veins of which are occluded by *thrombosis*, is as follows: the blood injected into the limb through its arteries, being not carried away through its veins, stagnates, and exhibits a tendency to escape from the parts whose capillary vessels are not strengthened and supported by tissues extraneous to their walls. Thus it happens, in such cases, that the capillary vessels of wounded, granulating, and ulcerating surfaces not unfrequently give way from the internal pressure of the blood, and parenchymatous hemorrhage is produced. Pathology in secondary period.

The following case, which occurred in the author's practice, affords an example of parenchymatous hemorrhage occurring during the *primary* period. It attended the operation of amputating the thigh, performed through tissues which had previously been disordered by the inflammatory process, and which had not yet been restored to a healthy condition. Case in primary period.

Case LXXXIII. *Secondary Amputation of Thigh performed for Gunshot Injury of Leg; Copious Parenchymatous Hemorrhage (Primary) from Surface of Stump; it was arrested by covering the Raw Surface of the Stump with Lint, soaked in Liquor Ferri Persulph.; Recovery.* — Lieut. C. H. Doerflinger, Co. K, 26th Wisconsin Vols., aged 20, and of

naturally fine physique, was wounded at the battle of Chancellorsville, May 2, 1863, by a musket-ball (cylindro-conoidal), which penetrated the left leg about four inches above the internal malleolus, fractured the tibia, and, passing downward, fractured the astragalus and calcaneum, emerging finally through the sole of the foot. He was treated in the field hospital for some time; but, when the troops moved, he was brought to the Stanton U. S. Army General Hospital, June 15th, 1863.

His foot and leg were then much swelled, the tumefaction extending up to the knee; the ankle-joint was open, and the wounds were suppurating freely. He was also thin and pale. The water dressing was applied, and a nutritious diet ordered.

June 18. — He was attacked by fever, ushered in by a chill.

June 19. — The fever continued.

June 20. — The foot and ankle are greatly swelled; the skin presents an erysipelatous blush; the superficial lymphatics of the leg and thigh are inflamed; they feel like hard cords, and the skin over them is streaked dark-red in color nearly to the groin; free incisions were made in the foot to relieve tension; cold applications to the leg and thigh.

June 21. — The lymphatic glands of the groin were swelled and painful. Prescribed ungt. hydrarg. et camphor.

June 24. — The inflammation of the lymphatics had subsided, and he was much better in every respect.

June 26. — The swelling of the foot and leg again increased, and

June 27. — The thigh was amputated by Assistant Surgeon G. A. Mursick, U. S. Vols., at the lower third by the circular method, the leg being so much swelled and inflamed that the operation could not, with propriety, be performed below the knee. At the place of operation the tissues were considerably swelled and inflamed. A large number of ligatures were applied. There was also a troublesome oozing of blood from the surface of the stump in the nature of a *parenchymatous hemorrhage*. After a time the wound of operation was closed, and the stump dressed; but the patient was directed to remain on the operating table. In a little while we were summoned to his aid on account of the profuseness of the flow of blood through the dressings. These were immediately removed, and the stump opened, for the purpose of ascertaining the source of the hemorrhage. It was then seen that the blood did not flow in distinct streams, but that it was poured out from the parenchyma upon the whole of the raw surface of the stump, by a process of general oozing, which, in the aggregate, constituted a stream of considerable size. The application of cold water, and even of ice, did not arrest this parenchymatous bleeding, and seemed to retard it but little. Finally, we covered the whole surface of the stump with lint soaked in liquor ferri persulph., and this proceeding speedily controlled the hemorrhage. The stump was left open to granulate from

the bottom, and to prevent any accumulation of pus therein. Afterwards the patient slowly recovered.[1]

Comments. — It is obvious that, in the foregoing case, the hemorrhage took place from the open mouths of the dilated capillary blood-vessels belonging to the inflamed tissues, through which the operation was performed. If these tissues had been healthy, the capillaries divided by the operation would have speedily closed their mouths by contraction, and thus all bleeding would have ceased soon after the principal arteries were tied. But one of the effects of the inflammatory process is to produce dilatation and destruction, more or less complete, of the contractility of the capillary vessels belonging to the diseased part, or, in other words, paralysis of the walls of these capillaries, and thus it happens that troublesome or even dangerous parenchymatous hemorrhage may be induced by the section of recently inflamed tissues, while performing such an operation as amputation of the thigh.

In the case of Joseph B. Hutchings, which is related in the the chapter on *osteo-myelitis*,[2] secondary amputation of left thigh was performed for a gunshot fracture involving the knee-joint. The operation was attended with the loss of a considerable quantity of blood. The hemorrhage was parenchymatous, the blood being poured out from the capillaries belonging to the swollen and inflamed tissues through which the operation was performed. It was controlled by the free application of liquor ferri persulph., and the stump was left open; but the patient died on the fifth day afterwards of exhaustion, occasioned principally by osteo-myelitis. Another case in primary period.

The next case is also an example of parenchymatous hemorrhage, which occurred from the surface of a thigh-stump immediately after amputation had been performed; but the loss of blood was so great before the bleeding was arrested, that the patient died in consequence of it. The account of said case was contributed by Dr. W. Clendenin, late Surgeon U. S. Vols. Case by Dr. Clendenin.

Case LXXXIV. *Gunshot Wound of Right Knee-joint; Secondary Amputation of Thigh; it was followed directly by very Profuse Parenchymatous Hemorrhage; Death; Autopsy; the Femoral Vein just below Poupart's Ligament was occluded by a Thrombus.* — Benjamin F. Black, aged 23, Co. A, 6th Ky. Infantry, was shot Saturday, September 19th,

[1] Vide *American Journal Medical Sciences*, April, 1864, pp. 368, 369.

[2] Vide Case XLIII. of that chapter.

early in the battle of Chickamauga; the following day was transferred to Chattanooga, and two days afterwards to Bridgeport, a distance of sixty miles; thence to Nashville, Tenn., occupying six days in the transport.

The ball had passed obliquely through the right knee-joint, and when the patient was admitted to hospital in Nashville, was laboring under high symptomatic fever, with swelling and acute tenderness of the joint; synovial fluid of a yellowish cast flowed from the wound. On the 2d of October, the patient was put under the influence of chloroform, for the purpose of examining the condition of the joint, and to give a free outlet to the fluids. Upon inserting the finger into the wound, a small portion of the patella was found to have been chipped out by the ball, and the joint opened so as to permit the finger to pass freely behind the patella. The patient continued to grow worse.

October 30. — Amputation of the limb was performed. No tourniquet was used, yet, after securing the arteries, *profuse hemorrhage of a parenchymatous character took place.*

The hemorrhage was of the most persistent character; it was finally arrested by a strong solution of the persulphate of iron, but not until such a quantity of blood had been lost as proved fatal at nine o'clock, P. M.

Post-mortem Examination. — In the stump a large abscess extended as high as the trochanter major, the whole of intermuscular spaces being filled with a sero-purulent fluid. *In the femoral vein, just below Poupart's ligament, a fibrinous clot was found, of sufficient size to completely prevent the blood from flowing through it.* No pus was seen here nor in any of the veins. The right side of the heart was entirely filled up with a fibrinous clot.

The liver, lungs, and all the other organs were sound.

Comments. — This case differs from the preceding, inasmuch as the femoral vein in it was occluded by a fibrinous clot a short distance below Poupart's ligament. The parenchymatous bleeding which followed the amputation of the thigh had therefore a twofold origin: 1st, the inflamed condition of the tissues through which the operation was performed, with the paralysis of the capillary vessels which accompanies that condition, and, 2d, the obstruction presented to the flow of blood from the limb back towards the heart, by the plug in the femoral vein. It is therefore not surprising that the hemorrhage was so intractable and profuse as to destroy the patient's life.

Femoral vein occluded by fibrous clot.

Again, the case of Lieut.-colonel Maxwell, No. LIII. of this essay, affords us an example of parenchymatous hemorrhage occurring during the *intermediary period* in the history

Case in intermediary period.

of a wound made by a surgical procedure. This officer had suffered a secondary amputation of his left thigh, performed at its middle third, on account of a gunshot injury involving the knee-joint. It required the application of twelve ligatures to secure all of the bleeding arteries. Capillary hemorrhage to the extent of about eight ounces occurred. It was arrested by opening the stump and painting its raw surface with a strong solution of the per-sulphate of iron, by means of a camel's-hair brush. This patient recovered.

In the following case, which came under the author's observation, parenchymatous hemorrhage occurred from a gunshot wound of the thigh during the *secondary period*. It made its appearance on the thirty-second day, and was accompanied by symptoms of pyæmia. On the following day, the patient died. The femoral, external, and common iliac veins were found to be *thrombosed* on making a post-mortem examination. Case in secondary period.

Case LXXXV. *Gunshot Wound of Right Thigh in its Middle Third; Bone apparently not injured; Bullet lodged; Parenchymatous Hemorrhage on Thirty-second and Thirty-third Days; Death with Symptoms of Pyæmia; Autopsy; Femoral, External, and Common Iliac Veins obstructed with Coagulated Blood (Thrombus), which, in Some Situations, was undergoing Spontaneous Degeneration, or Puriform Liquefaction.* — Private Benjamin Romig, Co. F, 6th Michigan Cavalry, was admitted into the Stanton U. S. Army General Hospital, September 25, 1863, for the treatment of a gunshot wound in the middle third of his thigh, received two days before. The ball penetrated the right thigh on its inner side, and, lodging in a deep situation, was not extracted. The wound had been treated with simple dressings, and appeared to be doing well.

October 11. — While making the usual morning visit to the patients in his ward, the attending surgeon found him perspiring very freely; he stated that he experienced a chill the night before followed by fever; ordered him to take quiniæ sulph. gr. xxx. in three doses; wound looking well, and the discharge healthy; afterwards he had no more chills, but sank into a typhoid condition, with symptoms of rheumatism in several joints; could not move his left arm, nor either of his lower extremities; complained of suffering acute pain whenever he was moved; the left knee was somewhat swollen; there was some œdema of wounded thigh (right); his tongue was dry, and covered with a thick yellowish-brown coating; could not be readily protruded; his skin was hot, yet generally moist, and often sweating freely; mental faculties sluggish; bowels loose, but no diarrhœa; stools most of the time dark-colored. Sometimes the fæces and urine were voided in bed without the knowledge

of the patient; his pulse ranged at about one hundred; was treated with quinine and iron, stimulants, beef-tea, etc., with a gradual improvement of the general symptoms. The tongue became more moist, the mental faculties brighter, the pulse subsided to about eighty, he could be handled without suffering much pain in the joints, and he acquired some appetite. Meanwhile the wounded limb grew more œdematous. It was not noticed as anything remarkable until about Friday, October 23. The surface of the wound looked well, but the discharge was tinged with a slightly greenish hue, and had some odor.

On Sunday morning, October 25, while the attendants had the patient up and sitting on a chair to allow his bed to be made, a sudden hemorrhage took place from the wound, amounting, in the opinion of his attending surgeon, to four or five ounces. It was apparently venous, judging from the color and character of the flow. It ceased spontaneously.

He was placed in bed, and soon afterwards had a chill, which lasted but a few minutes. From this time the patient began to fail rapidly. During the following night he had another chill. On the next morning (October 26), he had a return of the hemorrhage, and lost three or four ounces of blood. It again ceased spontaneously. He had several chills during the day. He continued to sink, and died about three o'clock, P. M.

Autopsy twenty hours after death. Lungs fastened to thorax by numerous old adhesions, moderately congested, otherwise sound; milk spot on anterior surface of heart; no other abnormity of that organ; blood watery and cherry-colored; liver bronzed from malarial fever, but exhibits no other abnormity; spleen moderately enlarged and somewhat softened; intestines presented nothing abnormal; right lower extremity much swelled and œdematous; on laying open the thigh and groin by incisions along the course of the femoral and iliac arteries, the chain of lymphatic ganglia is found to be very much enlarged in all its component parts; the walls of the femoral and iliac (external and common) veins very much thickened; in several situations where these vessels were opened by cutting with scissors, the walls appeared to be thickened to about three times the natural extent, as was remarked by Dr. Woodward; the upper part of the common iliac vein was occluded with a plug of coagulated blood, which firmly adhered to the sides of the vessel; its apex was conical in shape, and pointed upwards towards the heart; the interior of this plug was undergoing softening or fatty transformation; below or on the distal side of this plug the vein (common iliac, external iliac, and superficial femoral as far as examined) was filled with a dirty ashy-brown-colored liquid, consisting, apparently, of blood undergoing spontaneous disintegration after having been coagulated; the interior surface of the vein, in the same localities, had lost its polished and shining appearance, and was coated over with a yellowish-

brown-colored layer of what appeared to be plastic exudation; there was no purulent matter in the veins. The substance mentioned above consisted partly of a *puriform* matter, which, however, was not pus.

The vena profunda femoris was filled with a recent coagulum; the vena cava ascendens was stained dark red in color, with hæmatoidin; the femoral and other *arteries* were sound.

There was an abscess filled with dark-colored and very fetid pus, situated near the junction of the external and internal iliac veins, which also dipped down into the pelvis.

A remarkable case of parenchymatous hemorrhage is related in the chapter on osteo-myelitis.[1] It occurred in the person of a prisoner of war, named Tobias Beaver, who received a gunshot fracture of the thigh November 7, which after some time united, and the wound of the soft parts healed. Later still, osteo-myelitis supervened, the wound reopened, and his general health became much impaired. March 23, some hemorrhage from the wound occurred. He was weak, pale, and anæmic. March 25, he had quite severe hemorrhage, which was controlled by injecting liquor ferri perchlorid.; but the thigh swelled rapidly from effusion of blood within its interior. March 27, he died. The *autopsy* showed that the thigh was swelled to twice its natural size; that it contained a large cavity which extended from the synovial pouches of the knee-joint to the trochanter major, and was filled with blood mixed with pus, the quantity thereof being about a quart; that the orifice of said cavity was occluded by a hard coagulum; that the superficial femoral vein was filled with coagulated blood (*thrombus*) from the popliteal to the mouth of the profunda; and that the subcutaneous connective tissue was highly œdematous, occasioned, apparently, by the obstruction of the venous circulation.

Remarkable case in secondary period.

Bleeding proved fatal.

Produced by thrombus.

The same chapter also contains an account of another interesting case of parenchymatous hemorrhage which occurred during the secondary period.[2] James Hill, aged 49, underwent primary amputation of his right leg for gunshot injuries, which was followed by osteo-myelitis of the stump-bones. The stump itself sloughed, and he sank into a typhoid condition. On the eleventh day after amputation, parenchymatous hemorrhage from the stump, to the extent of about six ounces, occurred. It was arrested by the application of liquor ferri persulph. Three days afterwards he died of pyæmia. At the *autopsy* the popliteal and femoral veins were found to be filled with coagulated blood

Case in secondary period.

[1] Vide Case III. of that Chapter.

[2] Vide Case XXXIX. of that Chapter.

(*thrombus*). The knee-joint contained about four ounces of fetid pus. There was suppurative osteo-myelitis of the tibia.

It is worthy of special remark that in all of these cases of parenchymatous hemorrhage occurring during the secondary period, the bleeding did not take place until the patient's strength was much reduced, and either pyæmoid or pyæmic symptoms had made their appearance.

Two cases belonging to same class.

In the next case the occurrence of parenchymatous hemorrhage was preceded by well marked symptoms of pyæmia. Amputation was resorted to, but the patient sank and died a few hours afterwards. The case was attentively watched by the author.

Case LXXXVI. *Gunshot Fracture of Left Radius and Right Carpus; Parenchymatous Hemorrhage from Both Places of Injury on Twenty-third Day; Amputation; Death, preceded by Pyæmic Symptoms; Autopsy.* — Private Joram Chatfield, Co. E, 6th Ohio Cavalry, aged 32, was wounded by fire-arms in the cavalry combat near Middleburg, Va., June 21, 1863, while in the act of loading his weapon. He suffered a compound comminuted fracture of the left radius near its middle, and another compound comminuted fracture involving the right carpus. He was admitted June 24, 1863, to the Stanton U. S. Army General Hospital. Although his general condition was feeble, it was judged to be expedient to attempt to save the wounded limbs. The wounds were accordingly treated with the water dressing, and he was ordered to have a nourishing diet, with stimulants. On the 26th, 27th, 28th, 29th, and 30th, he had chills which were thought to be malarial in origin, and quinine was administered in full doses, and alcoholic stimulants were continued. He had but one chill per diem up to this time.

July 1. — Pyæmic symptoms supervened, with bronzed complexion.

July 6. — The symptoms of pyæmia are more marked; he had a chill; his complexion is yellow-colored.

July 13. — He had a chill; complexion still yellow-colored.

July 14. — *Parenchymatous hemorrhage*, profuse in character, took place from the wounds of the left fore-arm. The blood flowed in a steady stream. Its color was not so dark as that of venous blood, nor so bright as that of arterial blood. The liquor ferri persulph. injected into the wound, together with plugging and pressure, and the application of ice, having failed to control the hemorrhage, the left arm was amputated by Acting Assistant Surgeon C. H. Osborne, in the lower third by the circular method, as a remedy of last resort, the patient being under sulphuric ether. While the operation was being performed, *parenchymatous hemorrhage* attacked the wounds of the right wrist also.

It was decided best to amputate the hand, which was done without delay, the operation being performed at the lower third of the fore-arm. Very little blood was lost during these operations; but about sixteen ounces had been lost from the left fore-arm previous to the commencement of the operation. The pulse kept up whilst he was under the stimulating effects of sulphuric ether. Afterwards brandy was freely administered; but notwithstanding the great amount of stimulation, the pulse gradually became weaker and more frequent until death took place, about three hours after the operation.

Autopsy twenty-four hours after death. The internal organs were found to be healthy, with the exception of the rectum, which was slightly ulcerated. The veins of the amputated members were not examined, a circumstance which now I deeply regret.

Comments. — The local application of pressure and styptics having failed to control the capillary hemorrhage from the gunshot wound of the fore-arm in this case, it became necessary to employ some operative procedure in order to prevent the patient's bleeding to death before our eyes. Now, there were but two surgical operations at our disposal for the accomplishment of such a purpose, of which the first was ligation of the brachial artery, and the second was amputation of the arm. The last named proceeding was adopted with the hope that it would not only put a stop to the loss of blood, but also affect, beneficially, the pyæmic condition of the patient, by removing the principal source of the purulent infection.

The following case, which also occurred under the author's personal observation, presents us with another instance in which amputation, or rather reamputation, was resorted to for the arrest of profuse and uncontrollable parenchymatous hemorrhage. The patient died of pyæmia five days after the operation, and, on making a post-mortem examination, visceral abscesses were found in the lungs and liver.

Amputation for parenchymatous hemorrhage.

Case LXXXVII. *Parenchymatous Hemorrhage from a Stump; Reamputation; Death from Pyæmia Five Days after the Operation; Autopsy; Visceral Abscesses in Lungs and Liver.* — George W. Ferris, corporal Co. A, 36th Wis. Vols., aged 34, was admitted into the Stanton U. S. Army General Hospital, June 4, 1864, for recent amputation of the left arm at its middle third by the circular method, together with amputation of the right thumb at the carpo-metacarpal articulation, and of the second, third, and fourth fingers at their metacarpo-phalangeal articulation, by oval flaps. He informed us that he had been wounded by the explosion of a shell on the river Po, Va., eight days previously (May 27), that the

operations were performed the same day, and that his health was good at the time.

When he reached the hospital, the wounds of operation were suppurating freely, and the neighboring parts were considerably swelled and inflamed. It was thought to be expedient to apply ice dressings to the stumps, and to support him with nutrients, tonics (especially ferri et potass. tart.), and alcoholic stimulants.

June 6. — He was reported to be doing well.

June 12. — Profuse secondary hemorrhage, *parenchymatous* in character, suddenly occurred from the wound of operation on the right hand. The blood flowed in a steady stream. In color it was not so dark as venous nor so bright as arterial blood. Neither cold, nor astringents, nor pressure succeeded in arresting the hemorrhage. As a remedy of last resort, the fore-arm was amputated by Acting Assistant Surgeon W. B. Dick in its upper third by the circular method, sulphuric ether being employed as an anæsthetic. The constitutional state of the patient at the time of operation was not good. He was much debilitated. The hand, wrist, and lower part of the fore-arm were so much swelled, that the amputation could not, with propriety, be performed below its upper third.

June 14. — He was reported to be doing well.

June 15. — He had pyæmic chills, commencing on the previous day.

June 17. — He sank and died of pyæmia.

The *autopsy* revealed the existence of visceral abscesses, varying in size from a pea to a hickory-nut, in the lungs and liver; the medullary tissue in the stump-bones was found to be inflamed. We were induced to favor the performance of amputation in this case for the reasons already stated in connection with the case preceding it.

Summary of five cases in secondary period.

Comments. — We have thus related, with greater or less completeness, five cases of parenchymatous hemorrhage which occurred during the secondary period. In all of them the bleeding was preceded by prostration of strength, or general debility, with loss of flesh and pallor of the countenance; and distinctly marked symptoms of either the pyæmic or pyæmoid condition were also present when the flow of blood began, or fol lowed it soon afterwards. In three of these five cases the hemorrhage was connected with gunshot wounds inflicted upon the limbs in their continuity, and in the remaining two cases it occurred from unhealed stumps after amputation. The immediate cause of death in three cases appeared to be pyæmia, in one case, hemorrhage, and in the remaining case the loss of blood and the shock occasioned by amputation. In three cases the veins were examined at the autopsy, and their condition noted; and in all of them the principal veins

leading from the seat of the capillary hemorrhage were found to be occluded with coagulated blood (*thrombosis*). In the remaining two instances, both of which were amputations, the veins of the part removed by the operation were not examined, and therefore it was not positively known whether they were thrombosed or not. It is, however, inferred, from what has been ascertained in similar cases, that the veins proceeding from the affected part in these two instances were also obstructed with coagulated blood.

Capillary hemorrhage from granulating surfaces produced by venereal excitement, etc.

To the form of parenchymatous hemorrhage occurring during the secondary period, which has just been described, another must be added, namely: general capillary hemorrhage may be produced from the surface of granulating wounds by stimulus of any kind, such as the venereal excitement and excess in drinking.[1] The first-named is, however, the common, and the latter the occasional or exceptional variety of this additional form of parenchymatous bleeding that is met with during the secondary period in the history of wounds and surgical operations.

Scorbutic diathesis not a cause.

With respect to the occurrence of *parenchymatous* hemorrhage in *scorbutic* subjects during the secondary period, the writer has not observed that they are specially prone to suffer from it. This circumstance is probably due to the fact that the scorbutic dyscrasia lessens the coagulability of the blood, and thus diminishes the tendency to the formation of thrombi in the veins in such cases. And even during the primary and the intermediary periods the bloody discharge which so often stains the dressings of scorbutic wounds, is generally thin, watery, and *sanguinolent, rather than sanguineous.*

Persulphate and perchloride of iron.

Treatment of Parenchymatous Hemorrhage. — The general capillary bleeding which occurs in connection with surgical operations at the time of their performance, or soon afterwards, can, almost invariably, be promptly arrested by the copious application of a strong solution of the persulphate or perchloride of iron to the bleeding surface. The most effectual way of applying it is by laying on lint saturated with the styptic solution. If the seat of the hemorrhage is a stump that has been dressed, the bandages and sutures should be removed, and it should be opened without delay, for the purpose of allowing the

[1] Vide Holmes' *System of Surgery*, vol. ii. p. 86.

styptic to be applied directly to the bleeding surface. Afterwards, the stump should be left open at least until all danger of the return of the hemorrhage has passed away. In the absence or inaccessibility of styptics, it is probable that parenchymatous hemorrhage occurring during the primary and intermediary periods after amputation, might be arrested by the application of hot water to the bleeding surface. To be of use the water must be hot enough to coagulate albumen, that is, its temperature must be not less than 160° Fahr. It may be applied with a sponge. Should this proceeding fail to arrest the hemorrhage, the parts involved must be cauterized with a hot iron, and by so doing we may succeed in saving our patient's life.

Hot water as a hæmostatic.

When parenchymatous hemorrhage occurs during the secondary period from *thrombosis*, we have but little expectation of saving the patient, for his constitutional condition is generally such that recovery cannot take place. Under such circumstances the principal object of the surgeon is to keep the patient from bleeding to death in his presence, or to prolong life. If the application of styptics and pressure does not succeed in arresting such hemorrhage, then the surgeon must proceed either to amputate the bleeding member, or to ligate the main artery which supplies it with blood. Upon this point Stromeyer remarks: "The question of parenchymatous hemorrhage and its cause has already been discussed. A single amputation, practiced on this account, proved fatal rapidly; the ligature of the chief artery had but temporary success; the extraction of extensive loosened sequestra effected sometimes temporary stoppage of the hemorrhage, but death followed by pyæmia." [1] In some cases it is doubtless preferable to amputate, in others to ligate the main artery. If the patient is not already greatly reduced by systemic disease, and especially if pyæmia has not yet appeared, it is better to amputate; but if the patient is very low and affected with pyæmia, it is better to tie the chief artery.

Treatment when caused by thrombosis.

With regard to general capillary hemorrhage in granulating wounds which has been excited by stimuli such as the venereal excitement and excess in drinking, it may be promptly suppressed by the application of ice or styptics, such as the liquor ferri persulph., etc. The principal point in the treatment of such cases, however, is to prevent a recurrence of the hemorrhage by preventing a repetition of the cause which produces it.

When caused by venereal excitement, etc.

[1] Vide Stromeyer on *Gunshot Fractures*, p. 35. Am. ed., 1862.

CHAPTER THIRTEENTH.

ON CONSECUTIVE GANGRENE, OR MORTIFICATION RESULTING FROM THE INJURY OF BLOOD-VESSELS.

This Disorder is of not Unfrequent Occurrence and very Fatal Character. — Of Twenty-five Cases, Twenty-one died. — Its *Pathology.* — Its *Proximate Cause.* — Its *Efficient Cause.* — The Supply of Nutrient Blood may be diminished or suppressed in Three Distinct Ways. They are enumerated. — Arteries may become constricted or occluded by Gunshot Wounds in Two Distinct Ways. They are pointed out. — How Arteries become constricted in Consequence of *Contusion* of their Walls. — On Gangrene as a Result of the Division of Large Arteries. — On Gangrene as a Result of the *Ligation* of Arteries. — Five Cases and an Anatomical Specimen referred to. — The Large Veins of the Extremities. — How they may become plugged up; and the Consequence of such Obstruction. The Reasons why Consecutive Gangrene is often humid. — The Consequences of Venous Obstruction are well shown in Cases of Thrombosis. — Venous Occlusion alone but seldom occasions Consecutive Gangrene. It may, however, be an Important Adjuvant. — On Obstruction of the Collateral Channels as a Cause of Consecutive Gangrene. — The Office performed by the Collateral Vessels when the Main Artery is occluded. — On the Effect of Inflammatory Swelling upon the Development of the Collateral Circulation, when the Main Artery is closed. — Gunshot Fracture of Leg in Upper Third, when complicated with Severance of the Posterior Tibial Artery, is very apt to produce Consecutive Gangrene. The Reasons stated. — The Reasons also stated why Gunshot Wounds dividing the Femoral or the Popliteal Arteries are so frequently followed by Gangrene. — The Hunterian Operation, when performed for the Arrest of Hemorrhage from a Wound in the Continuity of a Limb, is more likely to be followed by Gangrene than the Old Operation. The Explanation given. — The Old Operation Advantageous in Another Respect. — The Effects of Deep-seated Swelling upon the Venous and Collateral Circulation when produced by Extravasated Blood described. — The Softening of the Brain which is produced by tying the Carotid Artery bears a Strong Resemblance to Consecutive Gangrene. — It should be called *Consecutive Gangrene of the Brain.* — The Objective Phenomena of Consecutive Gangrene occurring in a Limb described. — When left to Nature, but a Small Proportion of the Cases recover. The Reasons stated. — Amputation is our Principal Expedient in this Disorder. — To be successful, it should be performed as early as possible. — Other Rules concerning its Employment given. — In Cases of Consecutive Gangrene, a Line of Separation between the Dead and the Living Parts but seldom spontaneously forms. — An Illustrative Case. — Gangrene of Stump produced by compressing it with a Tight Bandage; Death on the Ninth Day after Amputation; the Mortification had travelled upwards nearly to the Trunk.

In the foregoing pages we have related thirteen cases in which the injury of important blood-vessels was followed by traumatic gangrene. We have also cited four specimens preserved in our Army Medical Museum, one case that occurred in the Crimean war, and seven examples mentioned by Mr. Guthrie, all of which belong to the same category. The ratio of mortality has been very great; for all of these twenty-five cases,

Of twenty-five cases, twenty-one died.

save only four, proved fatal. Now, without attempting to collect all the examples of this accident which occurred during the late War of the Rebellion, or to compile all the instances which had been recorded in the annals of European surgery, we are justified by the clinical facts already presented in stating that consecutive gangrene, when important blood-vessels are wounded, is an event of not unfrequent occurrence and very fatal character.

Its pathology.

When mortification occurs in consequence of the injury of important vascular tubes, it is because the *supply of nutrient blood* is so much *diminished* by the nature of the injury sustained by said tubes, that, in some or all of the parts to which they are distributed, the normal processes of cell-nutrition and the molecular transformations of the nutritive juices by which the calorification and the repair of worn-out histological structures are produced, are suddenly arrested in such parts from want of nutritive *material*, and then, molecular life having ceased, the putrefactive processes at once commence in said parts, and the gangrenous area enlarges constantly as the supply of nutrient blood grows less.

Its proximate cause. Its efficient cause.

Thus, the *proximate cause* of consecutive gangrene is the want of an adequate supply of nutrient blood in the affected part, and the *efficient cause* thereof is the lesion sustained by the vascular canals whereby the blood-supply is either very much lessened or entirely cut off.

Supply of blood diminished in three ways.

We will next briefly consider the several ways in which the blood-supply is seriously diminished or completely suppressed by certain traumatic lesions of important vessels. Most of these lesions have already been separately described at some length, and with considerable minuteness. We shall therefore in this place merely group them together, in order to obtain a general or comprehensive view of the subject, and learn the important lessons which it teaches. The blood-supply may be seriously disturbed in three distinct ways, in the extremities, as follows: —

1st. By the constriction or occlusion of the main artery.

2d. By the constriction or occlusion of the principal vein; and

3d. By the obstruction of the collateral channels when the former are occluded or much constricted. It is by the operation of these three factors, together or singly, that consecutive gangrene is produced in all cases where it occurs.

They are pointed out.

We have elsewhere shown that arteries become narrowed in their calibre (constricted), or even completely closed, by injury from gunshot projectiles in two distinct ways,

namely: 1st, by contusion of their walls, and, 2d, by complete division of them as tubes. With regard to contusion, we have shown that the sheath and coats of important arteries are sometimes bruised by the impact of small-arms projectiles in such a way that some of the *vasa vasorum* are ruptured, and blood is extravasated in considerable quantity between the sheath and the walls of the vessel at the place of injury, and thus it becomes compressed as a tube, and its bore diminished in size; or the inflammatory process is excited in the bruised walls of the vessel, inflammatory swelling of the bruised tissue occurs, and thus inflammatory narrowing (stricture) or even complete occlusion of the tube is produced at the place of injury.[1] In the case of Knoble (No. V.), the femoral artery was bruised by a minie ball, and its calibre was found to be compressed to one half its normal size by blood extravasated within the sheath of that vessel, and in consequence thereof the foot mortified. In specimen 2150, preserved in our Army Medical Museum, the popliteal artery has become occluded by the inflammatory process. A clot formed in the vessel at the place of injury. "Amputation was performed to obviate sphacelus and the patient recovered."[2] With regard to consecutive gangrene as a result of the complete division of certain large arteries by gunshot wounds, see pp. 76–78 of this essay. We will merely state again that this accident is very liable to occur when the femoral or the popliteal arteries are severed by gunshot projectiles, and that it is met with much more frequently in the lower than in the upper extremity.

Arteries constricted from contusion of walls.

Gangrene from division of large arteries.

Again, the ligation of large arterial trunks on the plan of Hunter, when performed for the cure of aneurism or for the arrest of secondary hemorrhage, is not unfrequently followed by gangrene. In the preceding pages we have related five cases, and referred to a specimen preserved in our Army Medical Museum, all belonging to this category.[3] In one of these cases the common iliac artery was tied for traumatic aneurism, in another the subclavian, and in still another the common femoral were tied for the same cause. In the remaining three instances the femoral was ligated for secondary hemorrhage from gunshot wounds. We therefore say that the occlusion of the above mentioned arteries by ligature on the plan of Hunter, when performed during the secondary period for the consequences of gunshot injury in the continuity of the limbs, is liable to be followed by gangrene, and

Gangrene from ligation of arteries.

[1] See pp. 28, 29, 30.

[2] See p. 29 of this essay.

[3] See Cases I., XLI., LVIII., LXIV., LXVII., and specimens 4084, 4085, mentioned on pp. 19, 20 of this essay.

in the lower extremity such a result is very apt to be produced. We shall presently return to this branch of our subject, and continue its discussion in connection with that of obstruction of the collateral blood-channels.

Plugging of large veins of extremities.

The *principal veins* of the extremities are liable to sustain the same kinds of injury as the corresponding arteries, and, in consequence thereof, they are also liable to become much narrowed in their bore, and sometimes plugged up with fibrine or coagulated blood. Besides, they not unfrequently become filled with a thrombus extending through a great space, during the secondary period of gunshot wounds, when the vessel itself was not injured at the outset.[1] Now, the immediate effect of such occlusion of the large venous canals is that the flow of blood through them upwards towards the heart is arrested, and the blood is compelled to seek new channels among the collateral veins in order to get out of the limb again. Thus, such a venous obstruction tends to produce stagnation of the blood in all the parts drained by the injured or thrombosed vessel. Thus the limb whose main vein is plugged by any morbid process, or occluded by any other means, speedily becomes tumefied and œdematous throughout its whole extent, and presents a striking resemblance in its general appearance to that of *phlegmasia alba dolens*. Soon, also, the subcutaneous veins are seen to become considerably enlarged or expanded, and blue-colored, from the force with which the blood seeks to escape from the limb through the collateral channels. Thus we perceive that venous obstruction tends to produce consecutive gangrene in a manner quite the reverse of arterial obstruction. The latter destroys the vitality of a limb by preventing the nutrient blood from going into it, the former by preventing the effete blood from going out of it. Thus we have explained to us the reason why consecutive gangrene is *dry* in some cases, and *humid* in others. When the mortification is produced entirely by arterial obstruction, it is dry in character; but when venous obstruction exists at the same time, it is humid. Diffuse inflammation of the cellular tissue may also cause the gangrene to be humid.

Consecutive gangrene often humid.

Venous obstruction from thrombosis.

The consequences of arresting the flow of blood in the principal veins of a limb are well shown by the phenomena attending *thrombosis* of these veins, an accident which the writer has met with in a considerable number of cases during the after treatment of gunshot injury.[2] Now, in such cases, the

[1] See Case LXXXV.

[2] See Case LXXXV. and others related in the chapters on Parenchymatous Hemorrhage, Osteo-myelitis, and Pyæmia.

limbs whose principal veins are filled with thrombus, become tumid and œdematous, and exhibit a remarkable tendency to the occurrence of parenchymatous hemorrhage if any solution of continuity is present, but they do not become gangrenous. The writer does not now remember to have seen a case in which the mortification of a limb was produced by thrombosis, although he is willing to admit that such a result is possible when the thrombosis is sufficiently extensive. In the case referred to above, gangrene did not occur, although the femoral, the external, and the common iliac veins had been filled up with a long thrombus for some considerable time before death.

Venous occlusion seldom occasions consecutive gangrene.

It is highly probable that occlusion of the principal veins of a limb, without corresponding occlusion of the main artery, seldom or never occasions consecutive gangrene, unless the superficial veins also are extensively obstructed by compression or by some other instrumentality. It is also certain that venous obstruction plays a much less conspicuous part in producing consecutive gangrene than has been supposed by some. It should not be forgotten, however, that venous obstruction, when coöperating with arterial obstruction, may assist considerably in causing consecutive mortification.

Collateral vessels.

On Obstruction of the Collateral Channels as a Cause of Consecutive Gangrene. — It is obvious that when the main artery of a limb is occluded by the application of a ligature, or by any other instrumentality, the limb itself must become gangrenous, unless the collateral channels shall suffice to furnish an adequate supply of nutrient blood, and thus perform the office of the occluded vessel. It is also obvious that in order for them to perform this vicarious office successfully, their capacity for conveying blood must become considerably increased, and consequently their size must become correspondingly enlarged. Again, it is obvious that whatever tends to repress the additional development of the collateral vessels required to perform this new office, or whatever diminishes the number of these vessels, tends in a corresponding degree to produce traumatic gangrene. Now, inflammatory swelling, especially when it occurs in parts that are inclosed by a dense, unyielding structure like the fascia lata of the thigh or the deep fascia of the leg, and is also considerable in amount, exerts a corresponding influence in restraining such a development of the collateral vessels. Thus, in Cases XIX. and XX., in both of which the posterior tibial artery was severed by gunshot wound in the upper

part of the leg, mortification occurred because the inflammatory swelling of the injured parts was so great as to compress and seriously obstruct the collateral vessels. If such swelling had not occurred, the collateral vessels, for example, the anterior tibial and peroneal arteries would undoubtedly have been able to expand their channels, and meet the emergency successfully. The principal reason why gunshot wounds which sever the posterior tibial artery in the upper part of the leg are so often attended with consecutive gangrene, is because such wounds are so often attended with much inflammatory swelling of the parts situated beneath the unyielding crural fascia, whereby the collateral vessels become compressed, and the flow of blood through them correspondingly obstructed.

Severance of posterior tibial artery in upper third.

Again, gunshot fracture occurring in the upper part of the leg, and complicated with corresponding severance of the posterior tibial artery, is almost certain to result in gangrene, when treated conservatively, for two reasons: 1st, because the inflammatory swelling of the injured parts is usually great, and, 2d, because some of the collateral vessels themselves are apt to be lacerated by the fracture splinters, or by the projectile itself, and thus their number becomes lessened.

Division of femoral or popliteal arteries.

We are now prepared to comprehend more thoroughly the reasons why gunshot wounds dividing completely the femoral or the popliteal arteries, and not attended with much hemorrhage, are so constantly followed by consecutive gangrene of the foot and leg. It is because the accompanying veins and the collateral arteries are also injured primarily by the projectile which severed the main artery, or because these vessels afterwards became compressed, and thus secondarily obstructed by the inflammatory swelling of the surrounding parts, arising from the gunshot lesion. We are also better prepared to understand the

Hunterian operation for wounds in continuity of a limb.

reason why the Hunterian operation, when performed for the arrest of secondary hemorrhage, or any other form of bleeding occurring from a gunshot wound of a limb in its continuity, is more liable to be followed by mortification of the limb than the old operation. It is because, when the main trunk is tied on the plan of Hunter, all the branches which are given off from the artery, between the place of ligation and the place of injury, are rendered nearly useless for sustaining the collateral circulation, since their natural blood-supply is cut off by the operation itself; but when the old operation is performed the function of these collateral branches is generally not interfered with. For

example, when the superficial femoral artery has been wounded by a gunshot projectile at the middle of the thigh, and the common trunk of the femoral is tied on the plan of Hunter, the profunda and its branches can take but little part in carrying on the collateral circulation; but when the wounded vessel is tied at the place of injury on the old plan, the profunda and its branches are not molested, and their important aid is secured for preserving the life of the foot and leg.

Moreover, the performance of the old operation in cases belonging to this category is advantageous in another respect, for it necessitates the division of the deep fascia of the limb to considerable extent, and thus relieves the tension produced by inflammatory swelling of the deep-seated parts, in a corresponding degree.

Deep-seated swelling produced by extravasated blood.

Substantially the same remarks as the foregoing should be made concerning the effect of deep-seated swelling upon the venous and the collateral circulation, when produced by copious extravasation of blood into the connective tissue of a limb from wound of its main artery. Like inflammatory swelling, this form of tumefaction tends to compress the accompanying veins and the collateral arteries, that happen to be in relation with it, and thus it tends to obstruct the flow of blood through these vessels to a corresponding extent. In Cases XLI. and LXVII., traumatic aneurisms were formed which were treated by ligating the main trunk on the plan of Hunter, and were followed by gangrene. If the old operation had been practiced in these cases, the consecutive mortification might have been avoided, for reasons that have just been stated; and for the additional reason that in tying the artery at the place of injury on the old plan, the aneurismal swelling would have been emptied of its contents, the collateral vessels would have been relieved from its pressure, and this obstruction to the flow of blood through them would have been promptly removed.

Consecutive gangrene of the brain.

Concerning the softening of the substance of the brain which so frequently follows ligation of the common carotid artery, we ought to say that it bears a strong resemblance in its origin and nature, at least in many cases, to consecutive gangrene occurring in the extremities; and the author is of the opinion that it would be useful in a practical point of view to call it *consecutive gangrene of the brain.*

When a limb is attacked with consecutive gangrene, the *phenom-*

Objective phenomena of consecutive gangrene.

ena are, in general, sufficiently obvious, and not liable to be misapprehended. The affected part assumes a tallowy-white, dirty straw-colored, marbled (motley), or brownish appearance, and dark-colored blebs not unfrequently form on its surface, its temperature falls considerably below the natural standard, its sensibility diminishes and finally disappears, its color becomes dark-brown or black, putrefaction occurs, and the odors characteristic of mortification are evolved.

Results when left to nature.

The *cure* of consecutive gangrene becomes possible only by the removal of the dead or dying part. When this process is left for nature to perform it, but a very small proportion of the cases is saved. Before any line separating the dead from the living tissues is distinctly formed, the patient generally sinks and dies from septæmia, because his system at large has become poisoned by the introduction of putrescent juices, or other decomposing matter, from the mortified part into the circulating blood. Against these sad consequences amputation, promptly performed, is the sole remedy. This operation, in order to be successful, must not, as a general rule, be delayed. It should generally be performed as soon as the consecutive gangrene appears, and the point at which it should be practiced, must depend upon the place of vascular injury. When, for example, the gangrene proceeds from occlusion of the posterior tibial artery, the leg should generally be amputated at the place of election; when caused by injury of the popliteal artery, the operation should be performed in the thigh as near to the place of arterial injury as practicable; but when it follows some lesion of the femoral artery, the rule which should guide the surgeon in selecting the place of amputation is not so fully settled. If that artery is wounded in the lower part of its course, it is generally best to amputate the thigh near the seat of injury; but when it is wounded in the upper part of its course, it appears to be preferable to operate at the place of election in the leg, as recommended by Guthrie, or at the knee-joint, notwithstanding that mortification may recur in the stump, because amputation of the thigh, at or near the hip-joint, for such a cause is almost inevitably fatal. It is believed that when amputation is seasonably performed at or about the knee-joint for gangrene resulting from wound of the femoral artery in the upper part of its course, the chance of recovery is better than it would be with the operation performed at or above the place of arterial lesion. Again, when the operation is practiced at the knee-joint, or at the place of election in the leg, for this

Amputation should be performed early.

cause, it becomes a matter of considerable importance to avoid embarrassing the collateral circulation, and hence care should be taken that the stump is not tightly bandaged, and that the collateral vessels are not compressed by any other means. By so doing, the risk of gangrene reappearing in the stump is correspondingly diminished.

But when, for any cause, a limb affected with consecutive gangrene from vascular injury is not seasonably removed by amputation, one of two results may follow: 1st, the patient may sink and speedily die from septæmia; or, 2d, a line of separation may form between the dead and living tissues, and the gangrenous part may be removed by a kind of spontaneous amputation performed through the agency of an ulcerative process. According to my experience, however, it does not often happen, in cases of gangrene produced by injury of blood-vessels, that a line of separation forms. Generally no such line makes its appearance. Generally well marked symptoms of septæmia are soon developed, and diffuse cellulitis rapidly spreads from the gangrenous to the sound parts, which in turn soon also become gangrenous, and thus, when life is sufficiently prolonged, the mortification may extend to some distance above the place of vascular injury.

Line of separation seldom forms.

The following case, observed by the author in his field-practice, illustrates this point better than many descriptive words. It also serves to show some of the bad consequences of the tight bandaging of stumps after amputation.

Case LXXXVIII. *Gangrene of Stump produced by compressing it with a Tight Bandage; Death on the Ninth Day after Amputation; the Mortification had travelled upwards nearly to the Trunk.* — April 10, 1865, a Confederate soldier, a prisoner of war, was brought in from the front to Burke's Railroad Junction, which was the depot of our army at the time of, and for a while after, General Lee's surrender. He had sustained amputation of the left leg at its middle, by the flap method, for gunshot injuries, and complained bitterly of pain in the stump. On removing the dressings, the bandages were found to be *very tight*, the parts compressed by them were swelled and gangrenous, and the swelling also extended above the knee.

The next morning, April 11, my attention was called to him by the surgeon in whose care he had been placed on arrival, — Dr. Snell, of the Confederate army. The patient was in a very bad condition. The stump was much swelled and very painful. The swelling extended not only as high as the knee, but also some distance up the thigh. The flaps were sphacelated, and the skin presented a yellowish-brown and

mottled appearance nearly up to the knee, with several large blebs, containing a dirty, yellowish-colored serum, scattered here and there on this surface. The mortification extended as high as the strangulating bandage had been applied, but no line of separation was yet established. The odor of gangrene was strong. He complained much of pain in the mortifying part. He also had a good deal of constitutional disturbance in the shape of irritative fever. But little change, either general or local, had taken place since the previous day. He informed us that his leg was amputated on the 7th, at the front, where he was wounded; that the stump was bandaged very tightly at the first dressing, so that it gave him much distress from the outset; that the stump could not be dressed again until he reached Burke's Junction on the 10th, only three days afterwards, when the gangrenous condition above described was discovered. I directed him to be removed to the Ninth Army Corps Field Hospital, which was then located in the neighborhood, as he would not bear transportation to the Depot Field Hospital at City Point.

April 14. — He is much worse, and very low; countenance almost hippocratic; the gangrene has extended up inner side of thigh almost to groin; odor of gangrene very strong; tongue dry; had been treated with tinct. iodine applied locally, and opiates, stimulants, and nutrients, administered internally.

April 15. — Says he feels better, and is now free from pain; but he is in reality worse, for the mortification has continued to spread, and he is also growing weaker.

April 16. — He died at four o'clock A. M. Towards the last, he became delirious.

I did not meet with any other gangrenous stump among the wounded, about 2,000 in number, who were brought to Burke's Junction. The mortification could not, with propriety, be attributed to any cause besides the undue compression of the stump, which resulted from tight bandaging, aggravated by inflammatory swelling.

In this case no line of separation made its appearance, the mortification was not limited to the part that was originally compressed, but a diffuse inflammation of the connective tissue of a gangrenous character supervened, and rapidly spread up the limb to the groin. Such were the local phenomena, while the constitutional symptoms were such as are produced by *septæmia*, at least by that kind of *septæmia* which results from the introduction of decomposing juices from a gangrenous part into the general current of the circulating blood.

ADDENDUM.[1]

Eleven Cases of Hemorrhage contributed by Prof. A. C. Post, of which Ten were Secondary, and One an Instance of Traumatic Aneurism.

It has been deemed advisable to present Prof. Post's valuable collection of cases in a separate form.

Case I. — Lafayette Siper, aged 32, wounded at Petersburg, April 2, 1865. He was shot through the left ankle. The leg was amputated the same day a little above the injury. Admitted into Armory Square Hospital, April 12. Secondary hemorrhage occurred from the stump, April 21. It was arrested by digital compression over the femoral artery, continued fifteen days. On the 23d April there was a slight chill, which was not repeated. The stump is now nearly healed. The skin is inflamed, and there are sinuses traversing it, probably indicating necrosis of the tibia.

Case II. — Henry Bowman, aged 18. He was run over by a street-car, on the 4th May, 1865, his ankle-joint being laid open. He was admitted into Armory Square Hospital on the same day, and the leg was amputated a little below the middle. The stump sloughed at an early period after the amputation. The sloughs have separated, but the remaining portions of the flaps are detached and flabby. The patient takes good nourishment and stimulants. He is feeble, but does not seem to lose ground. He has twice had hemorrhage from the stump, but it has been controlled by pressure over the femoral artery.

Case III. — John Lotz, aged 26, wounded March 25, 1865. Admitted into Stanton Hospital, March 30. Gunshot fracture of right fibula, a little above its middle. The tibia was uninjured. On the 8th, 10th, and 11th April, there was arterial hemorrhage from the wound. On

[1] The following original notes of cases and valuable observations on the subject of secondary hemorrhage could not be incorporated with the body of this essay, without separating them from each other, and thus doing injustice to their distinguished author. They are therefore placed together in an appendix, and thus their value as original observations, and in every other respect, remains unimpaired.

the 12th April a ligature was applied to the popliteal artery, immediately above its bifurcation. Partial sloughing occurred near the ankle on the 13th and 14th April. There has been no return of hemorrhage, and the patient is now doing well.

CASE IV. — This patient was shown to me by Dr. Delaney at the Campbell Hospital. Secondary hemorrhage occurred six weeks after a gunshot wound of the thigh. The source of the hemorrhage was the femoral artery, just as it was about to become popliteal. Dr. Delaney enlarged the wound, and tied the artery above and below where it had been opened. The operation had been performed eight days when I saw the patient, and there had been no return of the hemorrhage.

CASE V. — The history of this patient has already been related elsewhere.[1]

CASE VI. — A. A. Davis, aged 32, wounded in the knee March 31, 1865. The thigh was amputated on the field the same day. Admitted into Emory Hospital April 4. On the evening of April 6, hemorrhage occurred from the stump. On the morning of April 7, the femoral artery was tied at the place of election; there has been no hemorrhage since that time. The wound over the femoral artery is not yet healed. The ligature came away on the thirty-second day.

CASE VII. — Patrick Lanahan, aged 30, wounded April 6, 1865. The ball perforated his thigh from the inner and anterior to the posterior part, at the lower part of its upper fourth, without injuring the bone. Hemorrhage occurred two weeks after the injury. His surgeon cut down, and exposed the artery near the original wound; he applied only one ligature. The patient was admitted into Emory Hospital May 11th. There has been no return of hemorrhage since the ligature of the artery. The wound is nearly healed.

Dr. Mosely, the Surgeon in charge of the Emory Hospital, says that he has had about forty cases of secondary hemorrhage after amputation of the thigh, and that he has in every instance tied the femoral artery, and always with success.

CASE VIII. — Daniel T. Ritter, aged 19, wounded March 25, 1865. The ball penetrated his left leg five inches below his knee. Admitted into Finley Hospital March 28. Hemorrhage occurred about the middle of April. The surgeon cut down and tied the posterior tibial artery. About a week afterwards hemorrhage again occurred. Digital pressure was then kept up over the femoral artery, and there was no fur-

[1] Vide case of Henry Schatt, No. VIII. of this section.

ther return of the hemorrhage. There has been a free discharge of pus from the wound.

Case IX. — Charles Wiggins, aged 21, wounded March 25, 1865. Admitted into Finley Hospital March 28. The ball passed two inches below and an inch within the coracoid process of the scapula, and passed out through the body of the scapula, behind. On the 7th May hemorrhage occurred to the amount of fourteen ounces. The surgeon enlarged the anterior wound, and exposed the axillary artery below the clavicle, applying to it two ligatures, namely, one on the proximal, and the other on the distal side of the wound. There has been no recurrence of the hemorrhage, and the patient seems to be convalescent.

Case X. — Marion Wright, aged 18, wounded December 15, 1864. The ball entered the outer side of the right thigh, four inches above the knee, passed through the popliteal space, and was cut out from under the integument on the inner side of the leg, half way down. There were four hemorrhages within the first two weeks after the injury; at the end of that time Dr. Mola, at Beaufort, tied the femoral artery in Scarpa's space. There has been no bleeding since the application of the ligature. Admitted into Finley Hospital May 6, 1865. The patient is now convalescent, but his knee is rigid, being flexed at a right angle.

Case XI. — At Jarvis Hospital in Baltimore. The patient was wounded February 6, 1865. The ball entered his mouth, grazed his tongue, and was lodged deep in the neck. For a day or two after the injury there was some bleeding from the mouth, supposed to proceed from the tongue; it was not profuse. The patient walked about for six days after the injury; on the seventh day he had alarming hemorrhage, which occurred at intervals, until he died in the course of the the day. On examination, the ball was found lying on the right transverse process of the atlas, which was fractured. The ball had penetrated the right internal carotid and vertebral arteries; there was a false aneurism communicating with the internal carotid artery.

Prof. Post observes that of the above cases, the hemorrhage proved fatal in one (Case XI.). It is remarkable that the fatal hemorrhage did not occur until the seventh day, the internal carotid and vertebral arteries both having been opened. If the coats of these vessels were only contused by the ball, and the hemorrhage was occasioned by their sloughing, the period at which it occurred was unusually early. In the sixth case, the hemorrhage occurred on the seventh day; in the third and seventh, on the fourteenth day; in the ninth, on the thirteenth day; in the first, on the nineteenth day; in the eighth, on the twentieth day;

in the tenth, the time of the first hemorrhage is not stated, but four hemorrhages had occurred within two weeks; in the fourth, the hemorrhage occurred six weeks after the injury; in the second, the time of the hemorrhage is not mentioned; in the fifth, there is no mention made of external hemorrhage, but there was interstitial hemorrhage, and a false aneurism.

Comments by the Author. An analysis of Prof. Post's cases yields still other results that are sufficiently important to demand some consideration at our hands. We will present them as briefly as we can, consistent with clearness.

1. Most of the approved plans of treating secondary hemorrhage were tried in these cases. In six of them, or a decided majority, the ligature alone sufficed to restrain the bleeding. In two of them, digital or external compression of the main artery (femoral) was successfully employed; but they were both cases of secondary hemorrhage following amputation of the leg. In one of these, the compression was continued for fifteen days, so that it proved to be a formidable procedure for both patient and surgeon. In the other of these, the details are not so fully given. In one case (No. VIII.) where the posterior tibial was ligated, the hemorrhage stopped for a week, and then, returning, digital compression of the femoral was successfully employed. In one case (No. V.), popliteal aneurism existed, the popliteal artery having been perforated by a ball, and amputation of the thigh was resorted to with success. In the remaining case (No. XI.), the nature of the injury itself was such that no plan of treatment could obtain.

2. The plans of Hunter and Anel, and the "old operation," were each employed in two of the six successful cases. Thus, in Case No. III., the popliteal, and in Case No. X. the femoral, were tied on Hunter's plan. In Cases VI. and VII. each, the femoral was tied on Anel's plan. In Case No. IV., the femoral, and in Case No. IX. the axillary, were tied on the "old plan."

3. Cases I. and II. show the remarkable adaptability of digital compression for arresting secondary hemorrhage from stumps, especially when it is small or moderate in quantity.

4. Dr. Mosely's experience proves that Anel's operation may be advantageously employed in many instances of secondary hemorrhage from thigh-stumps, and probably arm-stumps also, when digital compression fails, and when, for some good cause, we do not wish to open the stumps themselves.

5. A success quite remarkable attended the performance of

these operations. But it does not appear from the record itself that all the subjects continued under observation long enough to show what the final result might have been. But even granting that some of these cases proved fatal after the reports were closed, it must still be conceded that the success was great.

6. The reader will observe that these deductions obtained from analysis of Prof. Post's contribution agree, as far as they go, remarkably closely with the conclusions to which we had already been led while discussing the treatment of secondary hemorrhage. (Vide Chapter XI. of this section.)

END OF SECTION FIRST.

SECTION SECOND.

ON THE

SECONDARY TRAUMATIC LESIONS OF BONE, VIZ: OSTEO-MYELITIS, PERIOSTITIS, OSTITIS, CARIES, AND NECROSIS.

INTRODUCTION.

THREE structures usually enter into the composition of bone. They are, 1st, the *Periosteum;* 2d, the *Osseous Tissue* proper; and, 3d, the *Marrow* or *Medullary Tissue.* These structures are distinct in an anatomical, but combined in a physiological point of view, and together constitute bone considered as a whole. Every normal bone in the human body, when fully developed, possesses each of these ingredients. In the fœtal state, however, the marrow does not appear until the osseous evolution is considerably advanced. At first the fœtal bones are solid, that is, they do not contain medullary spaces (cancelli), nor medullary canals, nor medullary tissue. Their development, however, is not complete until marrow is formed. Again: in abnormal states each of the structures mentioned above may disappear, to considerable extent, in consequence of injury or disease. Finally: they are convertible into each other by metamorphosis of their histological elements, as is seen in the process of growth, in the repair of injury, and when they are excited by inflammatory irritation.

The disorders which constitute the subject of this section, involve some one or more of the three constituents of bone, that is, either the periosteum, or the bone tissue itself, or the marrow, or, in certain cases, all of them combined. Indeed, the relation which exists between these several structures, from both contiguity and sympathy, is so intimate, that a morbid process which attacks one of them, is exceedingly liable to involve the others also, at least to some extent.

The *secondary traumatic lesions* of bone are mainly inflammatory in their nature, and will be discussed in this essay under the following heads: 1st, *Osteo-myelitis;* 2d, *Periostitis;* 3d, *Ostitis;* 4th, *Caries;* 5th, *Necrosis.*

We have awarded the post of honor to osteo-myelitis for two distinct reasons: 1st, because, according to our own experience, it is a much more destructive disorder, at least in cases where bone is injured, than either of the others; and, 2d, because its consideration has generally been neglected, until a very recent period. For example, I have often seen death produced by primary traumatic osteo-myelitis, but never by primary traumatic periostitis; while primary ostitis of traumatic origin is generally admitted to be of very rare occurrence. It is true that ostitis, properly so-called, does often occur in consequence of injury; but then it should generally be called secondary, because it is almost always preceded by inflammation of either the periosteum or the marrow. In such cases, the inflammatory process spreads from these structures to the osseous tissue proper; and I am thoroughly convinced, from observation and reasoning, that it takes its departure from the marrow much more frequently than it does from the periosteum. The conviction has been gradually forced upon me by experience, research, and reflection, that of all the inflammatory disorders of bone of a traumatic origin, the inflammation of medullary tissue is the one which possesses most importance, is the one which occurs most frequently, which dominates over the others, and which is most liable to prove fatal. The facts upon which this conclusion is based, are mostly related or referred to in the following pages.

CHAPTER FIRST.

OF OSTEO-MYELITIS.

Definition of the Term Osteo-myelitis. — Often met with during the Late War. — To be studied as it occurs in Civil as well as in Military Life. — Not as New Disease. — Bibliography. — Physiological Anatomy of the Marrow. — Marrow exists in all Bones. — Microscopical Anatomy. — No Endosteum. — Osseous Development not complete until Marrow is found. — Varieties of Osteo-myelitis. — Acute and Chronic. — Symptoms of Acute Form. — Pathological Changes. — Osteo-myelitis not a Variety of Pyæmia. — Several Illustrative Cases. — Causes of Osteo-myelitis. — First, General Causes, namely, Age, Sex, Occupation, Diathesis, Hospital Air. — Second, Special Causes, namely, Contusions, especially of Bones. — Contusion and Concussion of Marrow. — Ecchymosis of the Marrow. — Gunshot Fractures. — Compound Fractures. — Bisection and Excision. — Amputation. — Foreign Bodies in Medullary Canal. — Syphilitic, Strumous, and Rheumatic Diathesis. — Idiopathic Fever a Cause. — Occurring without any Appreciable Cause. — Transportation of Wounded. — Author's Experience in Several Campaigns. — Symptoms of Osteo-myelitis. — Non-traumatic Cases. — Character of the Local Pain. — Puffy Swelling. — Color of Skin. — Traumatic Cases. — Acute and Chronic. — Recapitulation of Symptoms. — Diagnosis. — Has not generally been recognized *ante mortem*. — Diagnosis of Chronic Form more simple. — Pathological Anatomy. — Carnification or Hepatization of the Marrow. — Cause of Change of Color in Marrow. — Apoplexy of Marrow. — Cause of Sclerosis. — Medullary Tube obliterated. — Pathology of Suppurative Osteo-myelitis. — Hepatization and Suppuration of the Medullary Tissue. — Only Different Phases of the Same Malady. — One Conservative and the other Destructive. — Gangrene of the Marrow. — A Result of a Higher Grade of Inflammation. — This Condition not often met with. — Illustrative Cases. — One Example of Mephitic or Spontaneous Gangrene of the Marrow. — Terminations, Complications, and Consequences of Osteo-myelitis. — Termination in Recovery, in Central Necrosis, in Necrosis in Totality, in Osteo-porosis, in Pyarthrosis. — May occur simultaneously in more than one Bone. — New Bony Growths, and New Osseous Tissue. — Acute Periosteal Abscess. — Abscesses in the Soft Structures, external to the Periosteum. — Thrombus. — Pyæmia. — Leukæmia. — Osteo-myelitis often proves fatal by inducing Extreme Exhaustion. — Treatment of Acute Osteo-myelitis. — Hygienic Measures. — Internal Medication. — Topical Medication. — Operative Procedures. — Incision, Trephining, Amputation, Exarticulation. — Operative Procedures especially required in the Chronic Form of Osteo-myelitis.

THE term *osteo-myelitis*, derived from two Greek words, ὀστέον, bone, and μυελός, medulla or marrow, signifies inflammation of the medullary tissue of bone.[1] Definition.

This disease was often met with in our military hospitals during

[1] It refers, not to inflammation of the marrow and the bone, but to inflammation of the *osteal* marrow, in contradistinction to inflammation of the *spinal* marrow.

Again, the terms *endostitis* and *medullitis* are sometimes used as synonyms of *osteo-myelitis*. But both of them are decidedly objectionable; the first because the bones do not contain an endosteum, *i. e.* an internal or lining membrane analogous to the periosteum, and therefore the term *endostitis* is clearly a *misnomer*; the second because the term *medullitis*, or inflammation of the medulla, does not of itself inform us what medulla is meant to be indicated as the subject of disease, whether the spinal, the osteal, or the medulla oblongata. If we employ it to repre- Objections to terms endostitis and medullitis.

This disorder frequently occurs.

the late War of the Rebellion; but precisely how often, no statistics yet collected have enabled us to determine. It was, however, beyond a doubt, one of the most frequent in occurrence and important in character of all those surgical affections which either delayed the cure or destroyed the lives of patients suffering from gunshot wounds of the osseous tissue, or from surgical operations involving bone. An account of osteo-myelitis, therefore, enters into the surgical history of the war not only with perfect propriety, but such history, without it, would be very incomplete.

In the following observations upon this important subject, the term osteo-myelitis will be employed in accordance with its literal signification, and its use will therefore not be restricted to the suppurative forms of the disease alone. For, as there are other kinds of periostitis besides the acute periosteal abscess which demand the surgeon's attention, so there are other forms of inflammation of the medullary tissue of bone besides diffuse suppuration, which belong to and constitute an essential part of the history of the disease in question. Numerous examples of the non-suppurative osteo-myelitis have been observed by our military surgeons; and any account of this disease as it appeared among the wounded in our army hospitals, which should describe only the acute suppurative cases, would be very incomplete, both in respect to the symptomatology and pathological anatomy of the disorder, and the practical considerations which have an important bearing upon its treatment.

Civil and military cases should be studied.

Furthermore, since osteo-myelitis is a disease which occurs not unfrequently in civil [1] as well as in military life, we propose to study this disorder as it shows itself in *civil* as well as in *military practice*, to the end that we may get more complete and accurate views of the subject, and obtain a more thorough knowledge of its varieties, causation, symptomatology, terminations, consequences, and treatment than we would acquire by pursuing a different course.

sent inflammation of the medullary tissue of the bone, we should prefix the word *osteo*, and write the term in full thus, *osteo-medullitis*, in order to definitely convey our meaning. The term *osteo-myelitis*, however, is preferable because it corresponds more closely to the original, or the Greek derivation. Moreover, the last named term has already been generally accepted throughout the world.

[1] Between November 20th, 1865, and March 23d, 1866, inclusive, a period of about four months, the writer personally saw and examined *ten* cases of undoubted osteo-myelitis occurring in civil practice, without taking much trouble to hunt them up. *Nine* of them occurred in hospital, and *one* in private practice. The histories of *seven* of them will be found related in the following pages.

The disease now generally called *osteo-myelitis*, is not a new thing. Cases and fragmentary accounts of it, under a considerable variety of appellations, have been placed on record by a large number of surgeons, commencing more than a hundred and fifty years ago. J. L. Petit alludes to it in his well-known work "On the Diseases of the Bones," anno 1705, in the chapter upon exostosis, and presents it as one of the effects of those osseous tumors which, in place of growing out from the surface of the bone, are developed toward the medullary canal.[1] In 1740, Gooch saw a patient having what we now know was osteo-myelitis, which he has described as "A case in which the tibia was affected to an extraordinary degree in a very short time, by a critical discharge of febrile matter upon a leg which had been fractured some years before."[2] Duverney, in a chapter where he treats of the longitudinal fracture of long bones, sometimes called a fissure or split, relates three cases of it, one of which, especially, leaves no room for doubt with regard to its real character.[3] Percival Pott, in a chapter devoted to an account of the "Separation or Destruction of Both Tables of the Skull from Contusion," and published first about the year 1765, gives at least two cases of osteo-myelitis involving the diploe.[4] Cheselden says, "Sometimes matter is formed in the large medullary cavities of the cylindrical bones, which constantly increasing and wanting vent, partly by corroding and rendering the bone carious, and partly by pressure, tear asunder the strongest bone in an human body, of which I have seen several instances."[5] Hey reports two cases of suppurative osteo-myelitis involving the tibia, under the title of "Caries of the Tibia." An abscess formed in the medullary canal in each of them, which emptied itself through a hole in the compact wall of the tibia, made by nature (spontaneous perforation). The first case occurred in 1786, in the person of a young lady whose age is not stated; the second in 1792, in a stout young woman of fifteen. Hey did not amputate, but enlarged the hole in the bone, and removed all the diseased tissues found inside. Both patients made good recoveries.[6] Abernethy states that he has seen suppuration of the diploe, and death of a portion of the bone, result from an injury done to the cranium.[7]

Not a new disease.

Bibliography.

[1] See also Nelaton's *Surgical Pathology* on this point.
[2] Gooch's *Surgery*, vol. ii. p. 349. London, 1792.
[3] *Elémens de Pathologie Chirurgicale*, par A. Nelaton, t. i. p. 595. Paris, 1844.
[4] Pott's *Chirurgical Works*, vol. i. p. 115 *et seq.* A new edition, London, 1779.
[5] *The Anatomy of the Human Body*, by W. Cheselden, p. 40. London, 1778.
[6] Hey's *Surgical Observations*, p. 26 *et seq.* London, 1810.
[7] Abernethy's *Surgical Observations*, vol. ii. pp. 68, 69. Am. ed., 1811.

In 1818, Hennen alluded very briefly to osteo-myelitis following gunshot injury, under the name of abscess in the medullary canal, etc.[1] In 1828, Craigie wrote as follows: "The medullary filamentous web is perhaps still more important than the periosteum in its morbid influence on bone. It is, in the first place, liable to inflammation; and, accordingly as this takes place in the medullary web of the cylindrical bones, or in that of their epiphyses, or of the short irregular bones, different effects result."[2] In 1831, M. Reynaud published a paper "On Inflammation of the Medullary Tissue of the Long Bones," in which he gives an account of five cases of that disease, all of which occurred in stumps after amputation performed for disease, and terminated fatally, without an exception.[3] In 1833, Mr. B. Phillips produced a brief but excellent article "On Inflammation of the Medullary Membrane after Amputation."[4] Dr. Carswell has given an excellent picture representing suppuration in the medullary tissue of the femur.[5] Cruveilhier says, "The phlebitis of the bones is one of the most frequent causes of visceral abscesses, following wounds or surgical operations in which the bones are involved."[6] He here, beyond a doubt, refers to the disease now called osteo-myelitis. In 1844, Nelaton gave a brief account of the same disease, following closely the memoir of Reynaud.[7] He used the term *osteo-myelitis*. Dr. Jules Roux says that Nelaton devised this term in 1834.[8] It has, therefore, been a long time in use (thirty-four years), although it is the modern designation of a disease which is yet but little understood. In 1849, Mr. Stanley wrote about it in a very interesting way, under the title of "Suppuration in Bone."[9] In 1855, a lengthy memoir on "The Osteo-myelitis of the Amputated," written by Dr. T. Vallette, a French military surgeon, was published at Paris.[10] M. Vallette has described the disease as he saw it in one of the large military hospitals at Constantinople during the Crimean War, especially among the wounded received directly after the battles of Alma and Inkermann. The disease appeared in an acute form,

1 *Principles of Military Surgery*, pp. 100, 115. Am. ed.

2 *Elements of General and Pathological Anatomy*, p. 564. Edinburgh, 1828.

3 *Archives Générales de Medecine*, t. xxvi. p. 161 *et seq.*

4 *London Medical Gazette*, vol. xiii. p. 189 *et seq.*

5 *Illustrations of the Elementary Forms of Disease*, fasciculus viii. plate 3. 4to, London, 1833.

6 *Anatomie Pathologique du Corps Humain*, t. i. liv. xi. p. 10.

7 *Elémens de Pathologie Chirurgicale*, t. i. p. 595 *et seq.*

8 *Mémoires de l'Academie Impériale de Medecine*, t. xxiv. p. 553.

9 *A Treatise on Diseases of the Bones*, p. 48 *et seq.* Am. ed.

10 *Recueil du Mémoires de Med. et de Chirurg. Militaires.* 1855, 2d ser., t. xvi. p. 230 *et seq.*

and proved very fatal. In a work published in 1859,[1] Chassaignac has devoted about thirty-one pages to an excellent discussion of osteo-myelitis occurring spontaneously, in which he has given an account of four cases of the disease in this form, observed by himself. In 1860, a long and very interesting memoir on osteo-myelitis was presented to the Academy of Medicine at Paris by Dr. Jules Roux.[2] M. Roux had charge of the naval hospital of St. Mandrier at Toulon in 1859, wherein he received about two thousand patients who had been wounded in the battles fought during the Italian campaign of that year. He saw and described the disease under its chronic conditions, that is, after it had existed a considerable length of time. M. Roux's memoir excited much attention among the members of the Academy, and caused osteo-myelitis to be the subject of discussion at two successive sittings of that body. This disease was also made the theme of a letter to the President of the Academy by M. Legouest,[3] and the text of an elaborate discourse by Baron H. Larrey,[4] the distinguished surgeon-in-chief of the French army in Italy in 1859. The most recent systematic treatise on surgery, of English origin, contains an account of osteo-myelitis, but it is very meagre and unsatisfactory.[5] Mr. Longmore read a very valuable paper on this disease before the Royal Medical and Chirurgical Society, February 28, 1865, an abstract of which was published in the "Medical Times and Gazette," March 11, 1865.[6] He refers to the observations of Drs. T. Vallette and Jules Roux, and the discourse of Baron Larrey, and also makes mention of certain practical considerations, which have occurred to him, with regard to the treatment of the disease in its chronic forms. Pirogoff, the illustrious military surgeon of Russia, briefly treats of osteo-myelitis in his valuable work entitled "Outlines of General Military Surgery,"[7] in the chapter on "Wounds and Compound Fractures of the Bones of the Pelvis and Extremities." We shall take occasion to refer frequently to this eminent authority. Dr. H. Allen,[8] U. S. Army, has recently published an interesting

[1] *Traité pratique de la Suppuration et du Drainage Chirurgical*, t. i. p. 467 *et seq.* Paris, 1859.

[2] *Memoires de l'Academie Impériale de Medicine*, t. xxiv. p. 537 *et seq.*

[3] *Bulletin de l'Academie Impériale de Medicine*, t. xxv. pp. 587, 588, 589.

[4] *Op. cit.*, p. 599 *et seq.*

[5] *A System of Surgery, Theoretical and Practical, in Treatises*, by various authors. Edited by T. Holmes, M. A., Cantab., vol. iii. p. 628. London, 1862.

[6] Vide *American Journal Medical Sciences*, July, 1865, p. 230 *et seq.*

[7] Vol. ii. Leipsic, 1863.

[8] Vide *American Journal Medical Sciences*, January, 1865, p. 30 *et seq.*

The writer has not aimed so much to present a complete bibliography of the subject, as to show that osteo-myelitis is not a new-fangled notion. Indeed, the time at his disposal,

article on the pathological anatomy of this disease, founded on twenty-three autopsies. This paper is, however, singularly defective in an important matter, namely, the description of the lesions themselves which the marrow presented, from neglecting too often to give the characteristic alterations in appearance upon which his own conclusions have been formed. In most of his cases it is impossible for the reader to decide, for himself, from the description given, whether inflammation of the marrow was present or not; and it is not improbable that in some of them a physiological condition was mistaken for a morbid state of the marrow. Thus, the value of this article is seriously impaired, and we are prevented from referring to it as often as we might wish. But the observations of many writers, besides those mentioned above, will also be quoted in the sequel.

It is only within the last twelve or fifteen years, however, that osteo-myelitis has fairly begun to attract the attention among surgeons which it really deserves. To this consummation the writings of Drs. Vallette, Chassaignac, Jules Roux, Virchow, Demme, and Pirogoff, together with the protracted discussion of the subject in the Academy of Medicine at Paris, already mentioned, have largely contributed. Among American surgeons the experience of the late War of the Rebellion has exerted a strong influence in the same direction. Still, the systematic treatises on surgery in general use contain either no account whatever, or only a very meagre one, of this important disease. But this circumstance can scarcely be considered as a matter of surprise.

A knowledge of this subject important.

Physiological Anatomy of the Marrow. — A clear understanding of the extent, appearance, and structure of the healthy marrow is necessary, in order to be able to recognize with certainty when it is diseased, and to comprehend the nature and importance of its pathological lesions. No apology is, therefore, necessary for introducing in this place a brief account of its physiological anatomy.

The medullary tissue is abundant in quantity, and extensive in distribution. It fills the medullary tubes of the long bones, the cancelli of their epiphyses, the larger Haversian canals of their compact tissue, the spongy structure of the short bones, and the medullary spaces in general, throughout the whole osseous system.

and the facilities at his command, would not permit him to exhaust the literature of the subject, if he wished to do it. Moreover, the foregoing references are quite sufficient for his present purpose.

It is found in all the bones of the body (Robin);[1] both those that are large and those that are small in size, and those that are regular and those that are irregular in shape. It is found not only in their cancellous structure and medullary spaces, properly so called, but it extends from their interior through the vascular canals as far as the periosteum, so that on tearing away one of the vessels from a vascular canal, it is seen to be surrounded by a small quantity of marrow, represented by medullary cells and a little amorphous matter. (Robin.)

Marrow exists in all bones.

The healthy marrow varies considerably in color, in certain of the bones, according to the age of the subject; but, in the other bones, it remains unchanged at all the periods of life. During infancy it has a red color in all the bones, and is commonly designated as fœtal marrow. During the adult period, however, it presents a yellowish or pale-yellow hue, instead of the red color of infancy, in the shafts of the long bones, as, for example, the femur, the tibia, the fibula, the humerus, the radius, and the ulna; while in the short, the flat, and the irregularly shaped bones, it still maintains the red color of the fœtal marrow. This yellow color of the medullary tissue, in the bones above mentioned, during the adult period of life, is occasioned by the presence of fat in it. Under such circumstances, the relative quantity or proportion of this material is always very large, and is generally stated as amounting to ninety-six per cent. The oil is not free, but contained in delicate microscopic cells, known as fat vesicles. The marrow, in all the bones except the long ones, is naturally red at the adult period of life, and it contains either no fat whatever, or only a small quantity of it. Thus much with regard to color.

Age modifies its color in certain bones.

Infantile marrow red.

Adult marrow pale-yellow in the long bones.

Yellow marrow rich in fat vesicles.

In respect to *consistence*, the medullary tissue is, when healthy, always very soft. The reader's attention is here especially called to this point, because we shall find in the sequel, that the marrow not unfrequently becomes toughened and indurated (hepatized or carnified) when subjected to inflammatory change, and that we can recognize the presence of the inflammatory process in this tissue quite as well by its increased consistence as by its altered color.

It is normally very soft.

Becomes indurated by inflammation.

When examined with the microscope, the medullary tissue is found to be composed, 1st, of medullary cells, which are its fundamental element; 2d, of an intercellular sub-

Microscopical anatomy.

[1] Vide *American Journal Medical Sciences*, October, 1865, p. 498.

stance, amorphous, homogeneous, and semi-transparent in appearance, which is interposed between the microscopic marrow-cells; 3d, of capillary blood-vessels; 4th, of nerves accompanying the vessels; and 5th, of delicate fibres of connective tissue, which are found only in certain situations, such as the shafts of the long bones, and the largest medullary spaces of the spongy tissue. Their presence, however, is not constant.

Cause of the red color.

The *red or fœtal marrow* owes its color, for the most part, to being composed chiefly of medullary cells, with some vessels and a small quantity of amorphous matter. The medullary cells which seem to form with the vessels about eight tenths of the whole tissue, do not appear to contain any drops of oil in their interior. (Robin.)

Cause of the yellowish color.

The *yellow marrow*, as already stated, owes its color to the presence of a great quantity of fat vesicles. They are, however, not arranged in lobules, separated one from another by partitions formed from fibres of connective tissue, as in the tela adiposa, and hence the fat vesicles of the marrow are more easily ruptured than those of the adipose tissue.

Cause of the gelatiniform appearance.

Besides these two varieties of healthy marrow, a third is sometimes met with, especially in dropsical and badly nourished subjects.[1] It is the *gelatiniform marrow.* It can, perhaps, hardly be called, with propriety, a perfectly healthy condition of the medullary tissue. It owes its peculiar jelly-like appearance to the fact that, in it, the medullary cells are relatively diminished in quantity, and separated one from another by a large amount of semi-transparent, homogeneous substance, having a gelatiniform aspect. In respect to color, this kind of marrow is sometimes gray, and sometimes it has a semi-transparent yellowish hue. The gray color depends upon the absence of fat, and the yellowish appearance upon its presence. (Robin.)

Arrangement of its blood-vessels.

The *medullary tissue is very vascular, much more so than the periosteum.* Its capillary vessels are arranged in meshes having about three or four times the diameter of the vessels themselves. The meshes are nearly of equal dimensions in all directions, and are polygonal, with rounded angles. They are most readily seen, in injected specimens, by washing away the marrow with a current of water, when they are found

[1] "The bones of a dropsical subject are always the least greasy and best adapted for skeletons." Vide Holden's *Human Osteology*, p. 9.

Through distinctions founded on color, M. Robin recognizes three varieties of marrow, namely, the *red*, the *yellow*, and the *gelatiniform*. These varieties are, however, not unfrequently found to be blended together, especially the first two of them.

lying against the osseous tissue. This has caused it to be said that the meshes are much more numerous in contact with the bone than elsewhere. The most delicate capillaries, found in the marrow, are larger than the ultimate capillaries of the periosteum, and of the osseous tissue. (Robin.) [1]

They freely inosculate.

Again: all the medullary vessels, both those of the apophysis and diaphysis, and the vessels of the compact substance, communicate in various ways, so that the vascular system forms one continuous whole throughout the entire bone, and the blood is enabled, possibly, to flow from any one part to all the others. Bichat accordingly found the marrow very well injected in an injected tibia, the nutrient arteries of which were obliterated. (Köllicker.) [2]

No endosteum.

The medullary tissue does not constitute an internal periosteum. There is no internal periosteum; no layer of fibrous tissue on the interior of the bones, enveloping the marrow and designed to separate it from the osseous tissue; but the marrow lies in immediate contact with the bony substance itself. (Robin.) [3]

The marrow contains but little connective tissue.

The fibrous element of the marrow is scanty in quantity, and found only in the medullary canals of the long bones, and in the largest medullary spaces of the cancellous tissue. Its fibres are remarkably fine and delicate. They are generally isolated, and cross each other in all directions, constituting a net-work. Next to the substance of the bone they lie closer to each other than elsewhere, without, however, forming layers or bundles, or an internal periosteum. Here and there, in the marrow itself, these fibres are arranged in loose wavy bundles, which are but slightly pressed against each other. (Robin.)

The medulla is developed subsequent to the osseous tissue, for, at one time in fœtal life, the latter is entirely compact, even in the long bones. Afterwards, however, medullary spaces and cavities are produced by the transformation of osseous into medullary tissue.

Osseous development not completed until marrow is formed.

As osseous tissue is formed out of periosteum and cartilage, so marrow is formed from osseous tissue, and the development of a bone consists not merely in the formation of osseous tissue, but it presupposes that the series of transformation goes beyond the stage of bone, and that medullary

[1] Vide *American Journal Medical Sciences*, October, 1865, p. 499.

[2] *Microscopical Anatomy*, p. 185. London, 1860.

[3] Vide *American Journal Medical Sciences*, October, 1865, p. 499.

All the recent investigators coincide with M. Robin in this statement. The idea of an internal periosteum appears to have been purely theoretical, and founded upon a supposed analogy between the wants of the exterior and the interior surface of a long bone.

tissue is produced. (Virchow.)[1] Thus, the medullary must be considered as supplemental to the osseous tissue.

Marrow continuous in adult bones.

The medullary tissue is continuous throughout the interior of an adult bone. The cancelli and the medullary spaces do not consist of shut sacs, but they communicate freely with each other. It is by means of this continuity of the marrow that inflammation is enabled, in some cases, to spread through it with very great rapidity.

Reflections.

Among the most striking and important anatomical facts relating to the healthy marrow are its *softness*, its *vascularity*, and its *richness in medullary cells*. Its softness exposes it to injury both in the nature of concussion and contusion from violence applied suddenly to the bone which contains it; and if its vascularity and richness in cells render it liable to become inflamed, when injured, they also afford the means of readily repairing the consequences of most of the traumatic lesions to which it is exposed. Its vascularity and richness in cell-formations also cause the inflammatory process to run a very rapid and destructive course in it (with suppurations), especially destructive in unhealthy subjects or under unfavorable circumstances as to hygiene and treatment.

Osteo-myelitis occurs in many different bones.

Clinical experience, especially in military surgery, has taught us precisely what might be inferred from the normal structure and distribution of the medullary tissue, to wit, that the development of osteo-myelitis is not confined to the medullary tubes of the long bones, such as the femur, tibia, fibula, radius, and ulna; for it has been met with in the diploe of the cranium, in the mastoid cells, in the lower jaw, in the sternum, the ribs and the bodies of the vertebræ, in the spongy epiphyses of the femur and tibia, and in the bones of the tarsus. There is also no good reason why it may not hereafter be found in

[1] *Lectures on Cellular Pathology*, p. 453. Am. ed.

On this point M. Ollier observes, "The external layer of the marrow is somewhat different in structure from those more deeply seated; it contains fewer fat vesicles and more of the variety of polynucleated (marrow) cells, to which Robin has given the name of *myéloplaxes*. It is, in fact, of more recent formation than the deeper portions of the marrow, and we are thus led to a view of the true function of this substance in its normal condition. As the bone is formed directly from the periosteum, the marrow is in turn formed from the innermost layers of its surrounding bone, whether by direct proliferation of the osteo-plasts, disembarrassed from their calcareous envelope by liquefaction of the fundamental (intercellular) substance (Virchow), or otherwise, cannot at present be positively determined. The fact is, however, established, that the medullary cavity grows at the expense of the inner layer of bone, not by a distention of its osseous envelope, but by a direct process of transformation, whereby the inner layers of bone disappear as others are added exteriorly by development from the proliferating or osteo-genetic layer of the periosteum." See *Traité Experimental et Clinique de la Régeneration des Os*, etc., etc., par L. Ollier, Chirurgien-en-chef de l'Hôtel-Dieu de Lyon, chapter second, vol. i. Paris, 1867. See also *American Journal Medical Sciences*, January, 1868, p. 147.

most of the bones not enumerated above, since it is believed that the medullary tissue enters, to some extent at least, into the composition of every bone in the body. (Robin.)

Its importance but recently understood.

It is only of late years, and since the aid of the microscope has been secured in prosecuting the study of histology, both healthy and morbid, that the importance of the medullary tissue to the well-being of the bones has been recognized with sufficient clearness and accuracy. Formerly the marrow in the canals of the long bones appears to have been looked upon as an oily substance, analogous in every respect to the subcutaneous adipose tissue, and, like it, a matter of quite secondary importance so far as the pathological processes in the bones are concerned.

Varieties of Osteo-myelitis. — The clinical history of this disease exhibits a wide variety with respect to the intensity and duration displayed by its evolution in different subjects. In some cases its activity is very great, and it runs through its whole course in a few days, while in other cases its progress is sluggish and obscure, requiring, not unfrequently, many weeks and even months to obtain a full development. Inflammation of the medullary tissue of bone may, on the one hand, be ranked among the most rapidly destructive of all the inflammatory disorders with which we are acquainted, while, on the other hand, it claims affinity with those that have an exceedingly slow career. There are but few parenchymatous inflammations which destroy life more speedily than acute suppurative osteo-myelitis sometimes does, and there are none which are slower in their progress than chronic abscess of bone. For the purposes of clinical study and description, and likewise for a lucid exposition of the facts upon which its treatment is based, it will be found convenient to recognize, at least, two varieties of osteo-myelitis, namely, the *acute* and the *chronic;* and accordingly the discussion of the cases of this disease in the coming pages will be conducted on the basis of its having an *acute* and a *chronic* form. But, at the same time, it should not be forgotten that this classification, although it is founded upon differences which actually exist in nature, is, in reality, artificial; that the cases of this disease, when systematically compared with each other in respect to their severity and duration, form a graduated series, represented at one end of the scale by the most acute, and, at the other end, by the most chronic type; that in the middle of this descending series it may be difficult to say whether some of the cases properly belong to the acute or to the chronic class;

Two types admitted, acute and chronic.

and, in short, that the inflammatory process in its essence, or, in other words, the histological transformations which may be produced by inflammatory irritation, are the same in both varieties, so far as the medullary tissue is concerned.[1]

The following case, which occurred in the author's practice, presents a good example of acute inflammation of the medullary tissue, following amputation, as it appeared among the inmates of our army hospitals, during the War of the Rebellion.

Case I. *Suppurative Osteo-myelitis (acute) following Primary Amputation of Left Thigh for Gunshot Injury; Death, Thirty Days after the Operation, from Pyæmia.* — Private Henry Stubblebine, Co. C, 96th Penn. Vols, aged 20, and of sound constitution, was brought to the Stanton U. S. Army General Hospital, May 8th, 1863. He had been wounded in the battle near Fredericksburg, Va., five days previously (May 3), and, on that account, had suffered primary amputation of the left thigh, at the lower third, by the circular method.

When he came to the hospital, his general condition was good; a water dressing was applied to the stump, and, his bowels being constipated, a dose of ol. ricini was administered.

May 11. — Oozing of blood from the stump was observed. It was now remembered that the stump had appeared to be swelled or distended ever since he was admitted to the hospital. The stump was then opened, and a quantity of coagulated blood, with which it was found to be filled, was removed. It was also left open to heal from the bottom by granulation, and to prevent any possible accumulation of pus in its interior.

May 15. — Suppuration free and laudable in quality; granulations healthy; the stump is also contracting. He continued to do well until —

May 27. — He has passed a restless night, and complains of having a good deal of dull pain in the stump, which he refers to the bone; but he has no febrile symptoms; ordered morphiæ sulph. in full doses, to allay the pain and induce sleep.

May 28. — The pain continues, but it is more severe; pulse quick and frequent; skin hot and dry; some pus is seen to be oozing from the marrow at the sawn end of the bone in the stump, and osteo-myelitis is diagnosticated; stump swelled; flow of pus from it diminished; prescribed potass. iodid. ℈i. dissolved in aqua camphoræ f. ℥iv., a

[1] Besides the terms *acute* and *chronic*, the words *diffuse* and *circumscribed* are not unfrequently employed by writers to designate certain forms of osteo-myelitis. When the word *diffuse* is used in this connection, it is generaly meant that the disease exhibits a strong tendency to spread, or that it pervades a large extent of bone; when the term *circumscribed* is employed, it denotes that the disease is localized or restricted in its operations to a circumscribed area of bone. *Acute* osteo-myelitis may be either *diffuse* or *circumscribed* in character; but the *chronic* variety of this disease is generally *circumscribed* in its operations.

table-spoonful to be taken every four hours, together with alcoholic stimulants. In the afternoon he had a chill.

May 29. — He was slightly delirious; had rigors and hot flushings occurring at irregular intervals; was rapidly becoming debilitated; same treatment to be continued.

May 30. — Delirium increased; skin yellow; pulse one hundred and thirty, and very feeble; he continued in about the same condition, but upon the whole rather failing until his death, which occurred June 2, thirty days subsequent to the amputation.

The stump was examined after death. A number of small abscesses were found in the muscular tissue of it. Pus was also found in the medullary canal of the femur, forming numerous little collections, which varied in size from a mustard-seed to a pea. The medullary tissue lying between these little abscesses was firmer or more consistent than natural, and had a dark-red color. The internal organs were not examined, because his friends were waiting impatiently to remove his body from the hospital.

It is, however, very probable that secondary visceral abscesses would have been found if the internal organs had been examined; for such accumulations of pus in certain of the viscera, especially the lungs and the liver, are very frequently met with in this class of cases.

Comments. — This case affords a strongly marked example of acute inflammation of the medullary tissue occurring in the bone of a thigh-stump. Its more important features are embraced in the following points. A healthy young man of twenty years suffered primary amputation of his thigh for gunshot injuries. Afterwards, he appeared to do tolerably well for a period of twenty-four days. Then symptoms of osteo-myelitis suddenly made their appearance, in the stump-bone. The first of these symptoms, in the order of sequence, was pain, dull, heavy, and aching in character, which appeared to the patient to be located in the bone. It was severe enough to make him restless, and to deprive him of sleep. On the next day this pain was more severe, and he had, in addition to it, much constitutional disturbance in the shape of irritative fever. The stump also became swelled, and the flow of pus from it diminished in quantity, and altered in quality; which tended to show that the soft parts external to the bone sympathized with the inflammatory mischief which had been lighted up in the marrow, or, speaking more exactly, that the inflammatory process had spread from the medullary tissue to the muscular and areolar structures of the stump. Pus was also seen exuding from the marrow at the sawn end of the bone in the stump; and this occurrence fully confirmed the diagnosis, as to the presence of

Symptoms of acute osteo-myelitis.

Diagnostic symptoms.

osteo-myelitis, which, aside from it, might have been deemed somewhat problematical by many surgeons. In the afternoon he had a chill.

On the next day (the third after the advent of the symptoms pertaining to acute inflammation of the medullary tissue), his condition was worse in every respect. He was beginning to be delirious, and his strength was failing rapidly. He also had rigors alternating with hot flushings, and occurring at irregular intervals. These latter symptoms belong to pyæmia, and serve to mark the time of its development. On the next day (the fourth), he was still more delirious, and still more debilitated. His skin had now assumed a yellowish hue, and the symptoms of pyæmia were still more strongly marked. Afterwards, he continued to sink, and died of pyæmia on the seventh day subsequent to the first appearance of the symptoms of acute osteo-myelitis.

Symptoms of pyæmia.

The diagnosis of suppurative osteo-myelitis in an acute form was verified on examining the stump after death. On splitting the bone lengthwise with a saw, it was found that the medullary tissue had undergone important changes in its appearance and condition. In place of the yellow hue and soft consistence, which normally belong to the marrow in the great canal of the femur, at the adult period of life, it had acquired a dark-red color and a tolerably firm or semi-carnified consistence, with numerous small, isolated abscesses, yellowish-white in color, scattered through its substance.

Pathological anatomy.

The symptomatology, as well as the morbid anatomy, presented by this case is very instructive. On the first day of his fatal illness the leading symptom was severe pain located in the stump-bone; on the second day, the most striking symptoms were increased severity of the bone-pain, irritative fever of a high grade, and the oozing of pus from the marrow at the sawn end of the stump-bone. These symptoms all belonged directly to acute suppurative inflammation of the medullary tissue, and to that alone. On the third day, however, rigors occurring at irregular intervals, prostration of strength and delirium also became prominent symptoms. On the fourth day, his skin assumed a jaundiced hue, and his strength diminished rapidly. These symptoms, especially the rigors occurring at irregular intervals, the rapid diminution in strength, and the icterode complexion belonged, not to osteo-myelitis, but to another disease, namely, pyæmia. The correctness of this statement is proved by the fact that pyæmia, attended by these symptoms, is not unfrequently met with when no inflammation of

the medullary tissue whatever is present, and by the converse fact that acute osteo-myelitis oftentimes runs its course without the development of this group of symptoms. In this case, then, these symptoms denoted that pyæmia supervened upon suppurative inflammation of the medullary tissue in the stump-bone, and they also indicated the precise time of such supervention. This patient got first osteo-myelitis, and afterwards pyæmia. His death was not directly occasioned by the osteo-myelitis, but by the pyæmia. Indeed, it is inferred, from what is known to have happened in analogous cases, that he would probably have recovered from the osteo-myelitis, but for the supervention of the pyæmia.

Osteo-myelitis preceded pyæmia in this case.

It is also probable, as has been already stated, that if an examination of his internal organs had been made at the autopsy, visceral abscesses would have been discovered in the lungs or liver, since this lesion has very frequently been observed in the cases which belong to this category.

The next case, which also occurred in the author's practice, likewise affords an example of acute inflammation of the medullary tissue, suppurative in character, and followed by pyæmia with the so-called metastatic abscesses in the lungs.

Case II. *Primary Amputation of Left Leg for Gunshot Fracture of Ankle; Suppurative Osteo-myelitis (acute); Death from Pyæmia Seven Days after the Operation.* — Private Michael Looney, Co. B, 1st Mass. Cavalry, aged 23, was admitted to the Stanton U. S. Army General Hospital, June 4, 1864, from the field, with loss of his left leg by amputation at the lower third. The circular method had been employed. He informed us that he had sustained a gunshot fracture involving the left ankle-joint, at Old Church, Va., May 31, and that the operation was performed on the next day, June 1. He also informed us that his health was not good at the time of operation.

June 6. — The patient is extremely prostrated, and the stump is sloughing. Prescribed alcoholic stimulants, nutrients, and disinfectants for stump.

June 8. — He died with the usual symptoms of pyæmia.

Autopsy. — The medullary tissue in the shaft of the stump-bone (tibia) contains a number of small abscesses. The tissue lying between the abscesses has a deep red color, and is firmer and tougher than natural. *There are several secondary abscesses in the lungs.* The other internal organs are normal.

Comments. — It may be stated here that, according to my own

observations, as I now recollect them, the so-called metastatic abscesses are found oftenest in the lungs, next, in point of frequency, in the liver, next in the joints, next in the spleen, and least frequently in the muscular tissue. The kidneys, however, in very rare instances, become the seat of this pathological lesion.

Secondary foci where found.

As already intimated, metastatic abscesses are very frequently met with in connection with acute osteo-myelitis; and, in such cases, pyæmia also is generally present. That disease is, however, not always present even under these circumstances; for, on the one hand, we not unfrequently see cases of pyæmia which prove fatal, and metastatic abscesses are not found at the autopsy, while, on the other, we sometimes meet with abscesses of the joints and of the muscles which appear to be metastatic in character and connected with osteo-myelitis, but are not attended by pyæmia, or, at least, are not attended by that disease in a fatal form.

Their connection with osteo-myelitis and pyæmia.

We shall find in the sequel that, although acute osteo-myelitis and pyæmia are frequently associated together in the same subject, the relationship is neither necessary nor constant; that not only does pyæmia occur without being preceded or accompanied by osteo-myelitis, even in cases where the medullary tissue has been wounded, but also that acute osteo-myelitis not unfrequently runs through its whole course without becoming associated with pyæmia in any part of it. This statement has been made at an early stage of the discussion for the purpose of avoiding a misapprehension concerning the connection between acute osteo-myelitis and pyæmia, which has sometimes occurred.[1] Thus much in the way of illustrating the *acute* form of inflammation of the medullary tissue.

Osteo-myelitis not a variety of pyæmia.

The following case, which also occurred in the author's practice, affords an example of the *chronic variety of osteo-myelitis*. It followed after a gunshot wound of the thigh with fracture of the femur, a form of injury which is frequently met with in the practice of surgery with armies engaged in active operations.

[1] It has been asserted by some that acute osteo-myelitis is not a distinct disease, but only a variety of pyæmia. Thus, Mr. Longmore remarks, "that in perusing Dr. Vallette's reports, the conclusion can scarcely be avoided that the so-called osteo-myelitis, in a large number of the instances referred to, must have been truly cases of pyæmic poisoning" (*op. cit.* p. 230). The author has also heard verbal statements of similar import made by medical men of prominence. To this doctrine, however, he does not subscribe. [illegible] that, although osteo-myelitis frequently becomes complicated with [illegible] reality, distinct affections, and he expects to fully substantiat-

CASE III. *Gunshot Fracture of Left Femur; Bullet lodged, and not extracted; Fracture united firmly in Two Months; Osteo-myelitis in a Chronic Form supervened; Profuse Parenchymatous Hemorrhage and Death nearly Five Months subsequent to Date of Injury; at Autopsy found Part of Bullet lodged in Medullary Canal, and the Marrow bright red in Color and carnified; a Large Cavity in Soft Parts of Thigh next to Femur filled with Blood, and containing Remainder of Bullet, which had been split by the Bone; Femoral Vein occluded by a Thrombus up to Mouth of Vena Profunda; this Obstruction produced the Fatal Hemorrhage.* — Private Tobias Beaver, Co. C, 57th N. C. (Confederate), aged 30, and of sound constitution, was admitted to the Stanton U. S. Army General Hospital, Nov. 9, 1863, from the field. He had been wounded on the 7th, in the battle of Rappahannock Station, Va., by a minie ball, which fractured the left femur in its lower third. On examining the limb, it was found that the projectile had entered at the inner side of the knee, about one and a half inches from the margin of the patella; that, passing upwards and outwards, it fractured the femur, seemingly with much obliquity, five or six inches above the knee-joint, and then lodged. It had not been extracted, and we did not succeed in finding its locality. There was no orifice of exit. The synovial membrane appeared to be unopened, although the bullet had passed along in close relation with it. The thigh was considerably swelled, but his general condition was favorable.

Treatment. — The limb was placed in Hodgen's *cradle splint*,[1] and extension was applied by means of a weight attached to the leg with long strips of adhesive plaster and a small rope, which, passing through a hole made at a suitable height in an upright standard fastened to the foot of the bed, held the weight aforesaid suspended by the side of the standard, and enabled it to draw the limb constantly toward the foot of the bed, with an amount of force which could readily be modified, as circumstances might require, by increasing or diminishing the weight. Counter extension was obtained by raising the foot of the bed on blocks, whereby the surface of the bed came to be an inclined plane sloping downwards towards the head. Thus, the patient lying in the bed would have a tendency to slide down the inclined plane towards the head, which, however, being counterbalanced by the weight attached to his leg in the manner above mentioned, and suspended at the foot of the bed, caused the two principal fragments of the broken femur to be drawn in opposite directions, and prevented their fractured extremities from overlapping each other to the detriment of the patient. The cold-water dressing was applied to the wound.

Hodgen's apparatus for compound fracture.

[1] For a description of this apparatus, vide *American Medical Times*, April 23, 1863, and Hamilton's *Military Surgery*, pp. 408, 412.

Subsequently a moderate amount of synovial effusion occurred in the knee-joint, and caused corresponding swelling.

November 21. — There were no untoward symptoms, except the synovial effusion above mentioned; directed the same treatment to be continued.

November 30. — The patient was doing very well. His health was good, and the synovial effusion in the knee had nearly disappeared; but the bullet was yet unextracted.

December 1. — The external wound has healed. A hard substance, feeling like a portion of bone, and perhaps the ball, was discovered apparently seated deep in the outer and back part of the thigh at the place of fracture; but there was so much uncertainty with regard to the nature of this substance, that it was deemed expedient not to cut down upon and expose it at this time.

December 15. — The fracture has united, and the patient's health continues good.

December 25. — The union has become quite firm. The projectile, however, still remains unextracted, and its location not surely known; general health excellent.

January 1, 1864. — The extension weight was now left off. He could move the limb very well. His health had been good all the while since he came to the hospital.

In a few days he began to leave his bed, and sit up in a chair. To-

Symptoms of chronic osteo-myelitis supervened.

wards the close of January, it was observed that the injured thigh was warmer than natural, and he also complained of having some pain in it. The abnormal warmth was noticeable over a large surface.

February 1. — The thigh has become swollen, hot, and more painful. The swelling was not circumscribed, but diffuse in character. Ordered the patient to keep his bed, and to have lotio plumbi et opii freely applied to the swollen thigh.

Feburary 14. — The swelling has partly subsided, but the lymphatic ganglia at the groin are enlarged, tender, and painful. Prescribed frictions of the thigh with oleum camphoratum.

February 25. — A red patch appeared upon the inner side of the thigh a short distance above the knee. It was hard and painful.

March 2. — The old wound [scar] opened spontaneously to-day, and discharged about two ounces of laudable pus.

March 8. — The wound continued to discharge a purulent fluid, but it was thin and pale. The swelling of the thigh was less, but his general condition appeared to be deteriorating, for he exhibited increasing pallor. He also had pain in the thigh.

March 20. — He was now quite pale and anæmic. His appetite was poor, and he said he felt weak. The swelling of the thigh had increased again, and there was some diffused redness of the skin. The discharge from the wound continued. It was now thin and flaky.

March 23. — He had some hemorrhage from the wound, but it was stopped without difficulty.

March 25. — He had a severe hemorrhage from the wound, which was controlled by injection of liquor ferri perchlorid. so far as the external bleeding was concerned. He was rapidly getting weaker and more anæmic. Parenchymatous hemorrhage.

March 26. — His face and lips have become blanched, and the swelling of his thigh has increased very much since yesterday, apparently from hemorrhage or extravasation of blood into its interior. No blood escaped externally. The swelling did not pulsate. Compression of the femoral artery did not lessen its size. He was now very pale and very low.

March 27. — He died of exhaustion one hundred and forty days subsequent to the infliction of the injury.

Autopsy. — The body appeared to be well nourished. The subcutaneous cellular tissue contained a considerable quantity of fat. The injured thigh was very much swelled. It was about twice as large as the sound one. On cutting it open, the cellular tissue was found to be highly œdematous. This condition apparently resulted from obstruction of the venous circulation. A firm or hard coagulum, about the size of half an egg, and caused by the liquor ferri perchlorid. that was injected for the purpose of arresting the hemorrhage on the 25th, occluded the track of the wound internally, and prevented any flow of blood externally. Beneath the fascia lata a large cavity, containing about a quart of blood mixed with some pus, was found. It surrounded the femur at the place of fracture, and extended from the subcrureal synovial pouch of the knee-joint up to the trochanter major. It was lined with a moderate amount of plastic material, or so-called exudation. At the bottom of this huge cavity, and on the inner side of the femur, the largest part of the ball (a minie) was found. A good-sized piece, however, had been split off from the side of it, which was not discovered till a later stage of the examination. The muscles were detached from the femur for a distance of about eight inches, including the place of fracture. The femoral artery and vein were separated from their muscular relations, and coursed through the cavity surrounded only by their sheath and some connective tissue. The vein was occluded with coagulated blood (thrombus), from the popliteal up to the mouth of the profunda. The artery was somewhat thickened, but it did not contain any emboli. No traumatic lesion of either artery or vein was discerned; but a spicula of bone projected from the seat of fracture in such a way that it might have wounded some of the lesser tributaries of the femoral vein. There is, however, no certain evidence that any such injury was produced by this osseous fragment. The hemorrhage ap-

Thigh much tumefied.

Large cavity containing blood, pus, etc.

Recent thrombosis of femoral vein.

peared to have been parenchymatous, and, to considerable extent, a consequence of the thrombosis of the femoral vein.[1]

Part of bullet in medullary canal.

The fragments of bone at the place of fracture were somewhat irregularly but firmly united. On splitting a portion of the femur lengthwise, the missing part of the bullet was discovered lying in the medullary canal at the place of fracture, surrounded by the new osseous tissue which united together the broken pieces of the bone. The medullary tissue was very vascular (hyperæmic), and presented a bright-red color, instead of the pale-yellow hue which the marrow of the femur normally possesses during the adult period of life. Its consistence was not soft, but, on the contrary, was decidedly firmer than natural. It was obviously in a state of inflammatory hepatization (sclerosis).

Marrow congested, red and carnified.

The abdominal and thoracic organs were healthy.

Comments. — Wounded on the 7th day of November by a cylindro-conoidal bullet, which fractured the femur with comminution, and, at the same time, inflicted no inconsiderable amount of injury upon the periarticular tissues of the knee, this patient, nevertheless, got along so well, that the broken bone was found to be united on the 15th of December, and firmly grown together on the first of January; and it was expected that he would soon be able to leave the hospital. Subsequently, however, a grievous disorder was slowly developed in his thigh, and terminated in the destruction of his life on the 27th of March. This case, then, had two distinct phases, of which the one embraced all the phenomena pertaining to the immediate effects of the projectile upon the bone and the knee-joint, together with the subsequent consolidation of the fracture, and included a period of about eight weeks' duration; and the other embraced the phenomena produced by the inflammation of the deep-seated parts of the thigh, which revealed itself late in the month of January, and ended fatally about nine weeks afterwards; but these two phases, as it was fully proven in the sequel, were connected with each other by a common bond of union, namely, the continued presence of a portion of the bullet in the medullary canal of the femur, where it had lodged at the time of injury.

Fracture united in two months.

Two distinct periods in its clinical history.

Now, each of these phases presents its own points of peculiar interest; and first among them, in a practical point of view, stands the simple and yet effectual method of treatment which was adopted for the fracture, — a method by

Utility of Hodgen's apparatus.

[1] Or, in other words, the hemorrhage appears to have been a consequence of the obstruction and occlusion of the femoral vein by thrombus.

which suitable extension was easily made and comfortably continued, by which the ends of the broken bone were readily held in apposition with each other; and their union was promoted so much that the consolidation of this case of gunshot fracture of the femur, although it was compound and comminuted in character, required but little more time for its production than that which is required in a case of simple fracture of the same bone, to obtain a similar result. We do not propose to discuss the treatment appropriate for compound fracture of the lower extremity, at length, in this place, because all such discussions properly belong to special treatises on that form of injury; still this point in the clinical history of the case seems to possess sufficient importance to require that even here it should not be passed over in silence.

Traumatic synovitis of knee.

Again: in a few days after the wound was inflicted, the knee-joint became considerably tumefied from synovial effusion. An inflammatory irritation seemed to have extended itself into the cavity of the joint from the track of the bullet, which ran along in close relation with its synovial sac. But the secondary traumatic synovitis, which, in this way, was lighted up, did not prove to be destructive in its nature; and, without any considerable amount of treatment besides absolute quietude and immobility of the joint, the activity of the disease abated, and its leading symptoms, such as the tenderness and the swelling of the joint, disappeared almost entirely by the first of December, a period of but little more than three weeks subsequent to the infliction of the injury. This feature of the case affords a good illustration of an important point in the clinical history of traumatic inflammation of the joints of the extremities, which is, that wounds of the soft parts entering into the formation of any one of them, not excepting even the knee, are, as a general thing, not difficult to manage, provided the loss of substance is not considerable, and the osseous tissue which enters into the structure of the articulation is not involved in the injury; that such cases do not require amputation, but should be treated conservatively; and that immobility of the joint under such circumstances is among the most useful of the various therapeutic agents at our disposal, if, indeed, it is not the most useful of them all.

Immobility of the injured joint.

Second period.

But the real difficulties in the management of this case made their appearance for the first time at the beginning of its second phase, in the latter part of January, when the injured thigh became somewhat painful and hotter than the sound

one, the unnatural warmth being, at the same time, diffused over a large surface.

Subsequently the pain and heat increased, and the limb also became swelled. The tumefaction was, however, not circumscribed within a small space, but, on the contrary, was spread over a large surface, more than one half of the thigh, and was flattened in shape. The skin investing it was not altered in color.

Adenitis of groin. Next, in about two weeks, the lymphatic glands of the groin became swollen, tender, and painful.

Wound re-opened. Eleven days afterwards a hard, circumscribed, red, and painful patch appeared upon the inner side of the thigh, a short distance above the knee; and in five days more, the old orifice of entrance reopened, and discharged about two ounces of laudable pus. A purulent discharge from this spot afterwards continued.

Six days later, it was noticed that he was "running down," as it is commonly called; that he was becoming pallid, notwithstanding he was allowed a nourishing diet and tonic medicines; and that the purulent discharge was also thinner and paler than natural.

Leucocytosis supervened. Twelve days later still, he had become quite pale and anæmic, and complained of debility, with loss of appetite. His spirits were low, and he was obviously failing at a steady rate.

Hemorrhage from the wound. Five days afterwards, he had severe hemorrhage from the wound, which rapidly increased his pallor, and reduced his strength.

Internal hemorrhage proved fatal. On the next day, a great hemorrhage or extravasation of blood into the interior of his thigh occurred, which completely blanched his face and lips, brought him very low, and destroyed his life on the following day, March 27. At this time no blood escaped externally.

Autopsy. On making a post-mortem examination, our opinion that the patient had died mainly from internal hemorrhage, was verified; for about a quart of blood was found extravasated within the parenchyma of the thigh. But for the occurrence of this hemorrhage, the patient's life might perhaps have been prolonged to a much later period. There was also an occluded condition of

Thrombosis of femoral vein. the femoral vein. It was filled with coagulated blood (thrombus) up to the mouth of the profunda. The coagulum was recent. There is scarcely room for doubt that the occlusion of the femoral vein by coagulated blood had much to do in the production of the hemorrhage. The blood continually

thrown into the limb by the arteries which were unobstructed, being unable to flow back towards the heart through the femoral vein on account of its *thrombosis*,[1] would seek an outlet elsewhere, for example, through the softened tissues of his diseased thigh; and thus the occlusion of the femoral vein, which itself was produced by the deteriorated general condition of the patient, occasioned a great hemorrhage, mainly parenchymatous in character, and, in that way, put a period to his life. This opinion with regard to the origin of the hemorrhage, is strengthened by the fact that the limb was highly œdematous, while the rest of the body was not at all so, and that the œdema could not, with good reason, be attributed to any other cause than the mechanical obstruction of the femoral vein with coagulated blood.

Pathology of the case.

The clinical history of this patient shows that the first step in his downward career was the occurrence of inflammation in the medullary tissue of his injured femur, in the latter part of January, which was denoted by the accession of some deep-seated pain, and a marked increase in the temperature of his thigh generally, without, however, being attended by any redness or any swelling at the outset, and for some time afterwards. Then the heat and the pain grew stronger as the osteo-myelitis became more intense, the inflammation also spread from the marrow to the soft parts lying exterior to the bone, and a tumefaction of the thigh appeared, which was flattened in shape, and spread over a large surface, but was not attended by any abnormal coloration of the skin. After this condition of things had lasted for a considerable time, a circumscribed suppuration, attended by induration and redness, occurred in the cicatricial tissue of the track made by the bullet. Under the prolonged influence of a diffused inflammatory irritation, this tissue broke down first, because it was newer than the rest, and thus it afforded the first example of suppuration in the soft parts of his thigh occurring after the advent of the osteo-myelitis.

With regard to the abscess which was formed in the muscles of his thigh and in relation with the bone, or rather its periosteum, it is not probable that it would have proved serious in its consequences if the bone and its medullary tissue had been perfectly healthy. The symptoms clearly indicate that the disease of the

[1] Virchow has proposed the employment of this term as a symbol to represent *the peculiar morbid process* by which a vein, or even an artery, may become extensively obstructed with coagulated blood, in its continuity, during life. Vide *Lectures on Cellular Pathology*, p. 233. The term thrombosis also embraces all the changes which such a clot may undergo subsequent to its formation.

medullary tissue preceded the formation of the abscess by a considerable interval of time. Moreover, when the abscess was first opened, the pus evacuated was laudable in quality and small in quantity (only two ounces). Afterwards, as his strength failed, and he sank into a *leucocytotic*[1] condition, in consequence of the osteo-myelitis, and an inflamed condition of certain of the lymphatic ganglia, together with other causes, the out-flowing pus became thin, flaky, and depraved. The cavity of the abscess steadily increased in size from melting away of the surrounding tissues. But this increase in the size of the abscess did not become marked or striking until near the close of the patient's life. It was then produced by the distension resulting from the sudden extravasation of a large quantity of blood into the suppurating cavity ; which was clearly denoted by the rapid increase of the tumefaction itself, and the quantity of blood which was found in the thigh after death.

Hepatized marrow.

It also should not be forgotten that, on splitting open the femur lengthwise at the autopsy, the medullary tissue was found to be extensively inflamed. It had a bright-red color, and was firm in consistence (hepatized or carnified). The former (*i. e.* the red color) was due in great part to increased vascularity, or active hyperæmia, of the marrow, and the latter was occasioned by the peculiar transformations of matter which had taken place in the substance of the marrow under the combined influence of a morbid excitement on the part of the medullary cells, in consequence of which they multiplied themselves with great rapidity, and of the stimulus produced by an increased vascularity of the medullary tissue.

Cause of the disease.

The fragments of the broken femur were firmly united. To what, then, must we ascribe the origin of the osteo-myelitis in this man's case? That disease was produced mainly, I think, by the presence of a portion of the bullet in the medullary canal, where, acting as a foreign body, it produced an

Fragment of projectile in marrow an irritant.

irritation of the marrow so persistent in character as finally to amount to a positive inflammation of the medullary tissue. That which is known to have happened in similar cases of gunshot fracture of the thigh, but wherein no foreign body had lodged in the medullary canal, induces me to believe that this patient would have recovered if a portion of the

[1] From *Leucocytosis*, a term employed by Virchow to designate a pale and depraved condition of the blood dependent upon disease of the lymphatic glands. He says, "The condition in which the increased proportion of colorless corpuscles in the blood appears to be dependent upon an affection of the lymphatic glands, I have designated by the name of *Leucocytosis*." Vide *Lectures on Cellular Pathology*, p. 201. Am. ed.

bullet had not penetrated the interior of the bone, and become inclosed therein. All the observations which I have personally had the opportunity to make on this subject, tend to show that foreign bodies, such as bullets and detached fragments of bone, when driven into the medullary canal and allowed to remain there, are not by any means innocuous. On this point that sagacious surgeon, Dr. Hennen, says: —

Foreign bodies in medullary canal very hurtful.

"There are some instances on record where the ball has remained quietly in this situation so long as twenty-five years; but in the majority of cases, a majority so vast as to admit of no shadow of comparison, the violence of the inflammation, the excruciating pain, the profuse suppuration, diarrhœa, and fever, lead to the removal of the limb as the only chance of recovery. A curious instance of a ball lodging in bone is given us by Paré. It is a very rare occurrence, but the case is valuable on many accounts. 'The King of Navarre,' says he, 'was hurt by a bullet in the shoulder a few days before the assault of Rouen, anno 1562. I visited and helped to dress him with Master Gilbert, of Montpellier, his own surgeon, and others; they could not find the bullet; I searched for it very exactly; I perceived, by conjecture, that it had entered by the head of the *adjutorium*, and that it had run into the cavity of the said bone. The most part of them said it was entered and lost within the body. Monsieur the Prince of Roche-upon-Yon, who intimately loved the King of Navarre, called me aside, and asked if the wound was mortal. I told him yea, because all wounds made in great joints, and principally contused ones, were mortal.' Paré remained steady to the prognostic, always declaring that the limb would fall into gangrene, which it did, and the king died on the eighteenth day after the wound. A dissection was ordered; and, much to the honor of Paré, the ball was found in the very middle of the cavity of the os humeri."[1]

Dr. Hennen's views.

Paré's case, ball in canal of humerus.

If the king's arm had been promptly exarticulated at the shoulder-joint, his life might have been saved; and that operation would doubtless have been practiced if the case had occurred at the present day; but at the time of Paré, that operation was not yet considered to be practicable. These conjectures remind me of the only plan of treatment which might have availed to save Beaver's life, namely, amputation of his thigh seasonably performed. The reason why it was not done was, we did not fully perceive the necessity of resorting to this operation until the hemorrhage occurred; and then it was too late to perform it with any hope of success, on account of the great prostration which was induced by the loss of blood. An explorative incision, carried down to the bone at the place of fracture,

Exarticulation at the shoulder.

Amputation seasonably performed.

[1] Vide Hennen's *Principles of Military Surgery*, pp. 102, 103.

might have been made with advantage in the latter part of January; and perhaps that proceeding would have furnished information of such a character as to have induced us to amputate on the spot.

With regard to the part of the thigh through which the operation ought to have been performed, it may here be stated that the removal of the whole of the diseased tissue being essential to a successful result, the limb should have been amputated sufficiently high up to get above the inflamed medullary tissue, and that, if it had been performed at the beginning of the osteo-myelitis, it might, perhaps, have been done in the continuity of the member; but if at a late period in the history of the disease, exarticulation at the hip-joint would have certainly been required, in order to get above the inflamed marrow, and save the patient's life. This practical question which is here but barely mentioned, is of high importance, and will be discussed at suitable length in another part of this essay.

At a late period exarticulation preferable.

The next case, which also occurred in the author's practice, affords another example of the *chronic variety of osteo-myelitis* produced by gunshot fracture. It differs, however, considerably from the preceding one in several important features, but, at the same time, presents a good illustration of what happened not unfrequently, in our military hospitals, to patients who were suffering from gunshot fractures of the long bones, and had their cure much retarded by the presence of this disease, but who ultimately got union of their fractured bones, after long delay.

Following gunshot fracture of femur. Recovery.

CASE IV. *Gunshot Fracture of Right Femur followed by Chronic Osteo-myelitis; firm Union at the Expiration of Five Months; Necrosed Bone discharged Several Months later still; Recovery with two and one half Inches' Shortening.* — Private Elisha Harrington, Co. I, 1st Mass. Vols., aged 26, and of sound constitution, was admitted to the Stanton U. S. Army General Hospital, June 15, 1863. He informed us that he had been wounded in the battle at Chancellorsville, May 3, by a minie ball, which passed transversely through his right thigh, in the lower part of its middle third, in a direction from within outwards, and somewhat downwards, fracturing the femur with comminution, in its course. He had been treated at Potomac Creek. When the patient was brought here (Stanton Hospital), his limb was in a fracture-box, whose bottom was so shaped as to constitute a double-inclined plane. At the same time, from the casualties of transportation or some other cause, his limb was very much out of shape, the fragments of the broken bone were

very much displaced, and he was complaining bitterly of the pain occasioned thereby. Moreover, his general condition was decidedly unpromising, as he was thin, pale, weak, and had diarrhœa, with a red tongue. He was also nervous and irritable. With regard to the treatment, his limb was taken out of the fracture-box already mentioned, and placed in *Hodgen's apparatus*;[1] moderate extension was also applied, the water dressing was ordered to the wounds, alcoholic stimulants and a nourishing diet were allowed, and opiates were prescribed in order to check the diarrhœa, and allay pain so as to procure rest at night. He also stated that he had had a good deal of pain in his broken thigh all along, and that about the 1st of June a fragment of dead bone, about half as large as his thumb, was discharged by suppuration.

Hodgen's apparatus for gunshot fracture of lower extremity.

June 18. — He is very irritable, and complains of suffering very much from the extension of the broken limb; ordered the extending force to be taken off, but the other treatment to be continued. After this date he slowly improved.

July 1. — The patient is now improving decidedly. The wound of exit is healed, but that of entrance is still open. He is also more cheerful and hopeful.

October 2. — His general condition is much better. The fracture is firmly united, and he goes about on crutches. The amount of the shortening, as determined by measurement, is *two and one half inches*. He got a furlough for sixty days. He subsequently reported that while absent from the hospital on this furlough, a flattened fragment of the bullet was extracted about the 1st of November; and again that a small fragment of bone was discharged by suppuration about the middle of December.

March 11, 1864. — He returned from furlough. A few days afterwards a very small fragment of necrosed bone was extracted through the orifice of entrance, which had not yet become closed.

March 26. — He now walks well with the aid of a cane alone. He is also in good flesh and spirits. The atrophy of the injured limb has nearly disappeared, and it is now almost as large as the sound one. The deformity is moderate, and consists in bowing somewhat, outwards and backwards. The wound of entrance is still slightly open, and discharges a small quantity of laudable pus. It has never been entirely closed.

June 1. — He was discharged from the service in good condition.

Comments. — Was this in reality a case of chronic osteo-myelitis? Was there really in it such an inflammation of the medullary tissue of the femur, at and in the neighborhood of the place of fracture, as retarded the cure, and likewise placed the patient's

[1] For a description of this apparatus, vide *American Medical Times*, April 23, 1863, and Hamilton's *Military Surgery*, pp. 408, 412.

life in great peril? To what conclusion in respect to the diagnosis will a rigid interpretation of the symptoms, which were developed both generally and locally, lead us? What other disease besides osteo-myelitis will account satisfactorily for *all* the symptoms that were present? In the first place, with regard to his general symptoms, the emaciation, the pallor, the debility, and the disturbance of his nervous system, associated with diarrhœa, were so well pronounced that, at one time, I expected daily to see him fall into a hopelessly pyæmic condition; and clearly indicated that the disease, whatever might be its appropriate name, was very severe in its nature. In the second place, with regard to the local symptoms, the pain, the heat, the swelling, and the discharge of pus from the wounded thigh, denoted that the disease was an inflammation, and was located in the thigh at and about the seat of the injury. In the third place, the subsequent exfoliation of necrosed bone showed that the inflammation was one which directly involved the vitality of the osseous tissue, and therefore was doubtless seated in one of the structures which enter into the composition of the living femur considered as a whole. The focus or centre of the inflammatory process in this case, then, must be sought for in either the periosteum, the osseous tissue itself, or in the marrow. The inflammation did not have its chief seat in the osseous tissue, because the pain was not severe enough for that, and besides the general symptoms were not such as are produced by chronic ostitis alone. It did not belong especially to the periosteum, because the general symptoms were such as only one variety of periostitis ever occasions, to wit, *the diffuse;* and exploration of the wound showed conclusively that diffuse inflammation of the periosteal membrane was not present. Furthermore, the fragments of necrosed bone that came away did not possess the shape or appearance of those which are produced by an extensive detachment of the periosteum. Finally, I believe the inflammation in this case involved principally the medullary tissue, because it did not have its chosen seat in either the periosteum or the osseous tissue, while, at the same time, it was obviously connected very closely with the broken bone, and because, on making autopsies of the fatal cases of gunshot fracture of the thigh which had presented essentially the same symptoms and the same general features as the one now under consideration, I have uniformly found the marrow to present evident traces of the inflammatory process when it was exposed to view by splitting the fractured bones lengthwise with a saw.

Diagnosis by exclusion.

The symptoms in this man's case were undoubtedly very much

aggravated by the injury unavoidably done to the broken thigh in transporting him from the Depot Field Hospital of the Army of the Potomac, at Potomac Creek, to the General Hospital at Washington, about six weeks subsequent to the infliction of the wound. The effect upon the soft parts of the motion among the fragments of bone not yet united, which is almost inseparable from the hurried transportation of large numbers of the wounded, such as not unfrequently occurred during the war, is to aggravate a preëxisting inflammation of the soft parts surrounding the place of fracture, or even to excite that process in them, *de novo*, if perchance it has not already been lighted up therein, which in turn may spread from these soft parts to the neighboring medullary tissue, and serve to kindle afresh or to intensify an inflammation already existing there. It should be recollected that apparently from the casualties of transportation, this patient's limb was very much out of shape, that the fragments of broken bone were very much displaced, and that he was complaining bitterly of the pain occasioned thereby when he came to the General Hospital. There is no doubt in my mind that this patient's condition was much worse at the time of his admission to Stanton Hospital than it was when he left Potomac Creek; and there is also no doubt that this aggravation of his malady was occasioned mainly by injury sustained while being conveyed from the one place to the other. I consider the subject of transportation of the wounded, especially in military practice, as a matter of very great importance even in its relation to the development of osteo-myelitis, and shall therefore take occasion to discuss it more fully in another place.

Inflammation of marrow aggravated by transportation.

Transportation a subject of importance.

The following case is an excellent example of *chronic osteo-myelitis* following one of the major amputations of the lower extremity.

Case V. *Chronic Osteo-myelitis of Tibia; following Primary Amputation, and Sloughing of Stump; Necrosis; Extraction of the Loose Sequestrum; Excision of the Club-shaped End of the Stump-bone.*— November 22, 1865, a discharged soldier, who had suffered amputation of his right leg, presented himself at the surgical clinique of Prof. John W. S. Gouley, at the University Medical College, with a tumefied, club-shaped, ulcerated stump, the tibia of which contained a good-sized piece of necrosed bone. The following is an account of his case: Francis McQuaid, formerly a private in Co. H, 95th N. Y. Vols., an intelligent young man, aged 22, and free from constitutional taint, states that he was wounded in the

right leg, by a minie ball, in front of Petersburg, Va., June 18, 1864; that the projectile fractured both bones near the ankle-joint with much comminution; that, in consequence of the injury, the leg was amputated a little below its middle by the circular method, in the Field Hospital, six or eight hours after the injury was inflicted; that, on the next day he was conveyed to the Depot Field Hospital at City Point, where he remained twelve days; that he was taken from thence to Washington, and admitted to the Campbell U. S. Army General Hospital; that the stump had done well, and was nearly healed, when, five or six days after he had entered Campbell Hospital, the stump began to slough at its end; that six days elapsed before the sloughing or gangrene was arrested; that during this period he became reduced a great deal, and was brought so low as to get a bed-sore. He states, furthermore, that the sloughing was treated at first with a solution of the permanganate of potassa, next with nitric acid applied to the gangrenous surface, and finally bromine was employed. He also states that the sloughing process, when arrested, had caused some protrusion of the bone; that the ulcerated surface left by it healed but slowly; that the stump has never been entirely healed up since then; that pain in the stump was a prominent symptom during nearly all the time he was at the Campbell Hospital; that he was discharged from the service at said hospital November 29, 1864; that the stump, although it was not entirely healed, did not give him much trouble at that time, aside from the pain in it; and that it was not swelled, but appeared to be smaller than the corresponding portion of the sound leg. Several scales of bone exfoliated while he was at the Campbell Hospital.

He came directly to New York City, and started a shop for the sale of newspapers and periodicals. Afterwards the stump did not do so well as it had been doing. The pain in it became greatly increased. His business compelled him to walk a good deal, which he thinks was the principal cause of the increase of the pain. During the winter the pain in the stump was so severe as to deprive him of sleep a good part of the time. The pain was always worse at night, and sometimes it was accompanied by twitchings and startings of the whole stump. The pain seemed to be located, for the most part, in the stump-bone. Last February or March an attack of erysipelatous inflammation supervened in the stump. An opening formed spontaneously, a quantity of thick matter was discharged, and in about three days' time the inflammation subsided. With the advent of warm weather the pain in the stump diminished in severity; but it still continued to be quite troublesome, especially in the night-time. It ceased, however, to deprive him of sleep.

Symptoms of chronic osteo-myelitis; pain, etc., etc.

Now (November 22, 1865), the stump appears to be very considerably enlarged, and club-shaped at the end. It measures fourteen and three-fourths ($14\frac{3}{4}$) inches in circumference, while the

Stump club-shaped.

sound limb at the same point measures but thirteen (13) inches around it. A large non-granulating, indolent-looking ulcer is situated on the end of the stump. It is irregularly oval in shape, having a long diameter of two and three fourths ($2\frac{3}{4}$) inches, and a short diameter of one and one half ($1\frac{1}{2}$) inches. The long diameter of the ulcer extends, almost transversely, across the end of the stump. The ulcer is surrounded by a broad areola of cicatricial tissue, having a glazed, shining, bright-red color. On the base of the ulcer the blackened end of a sequestrum is seen to protrude somewhat. On taking hold of it, it is found to be loosened, but not liberated. About three inches above the end of the stump and on its inner (tibial) side, there is a small circular opening, with a pouting margin in the soft parts, which communicates with a cloaca; and on introducing a probe, dead bone is felt at the bottom. The end of the stump discharges a good deal of thin, dark-yellowish, stinking matter. The hole in the side of the stump discharges a thin, yellowish matter. He says the stump is still painful, especially in the night-time.

Stump-bone contains a sequestrum.

November 28. — Prof. Gouley performed the following operation for the relief of this case at his clinique to-day. The patient being etherized, he liberated the sequestrum by suitable in-

Extraction of the sequestrum.

FIG. 2.

Exterior View of Sequestrum.

FIG. 3.

Interior View of Sequestrum.

cisions, and extracted it from the end of the stump with a necrosis forceps. It was about four inches long, and embraced about one half of the circumference of the medullary tube. It was thin, and presented an uneven and eroded appearance on both its outer, or convex, and its inner, or concave, surface. Although it was obviously a specimen of central necrosis, there were no vestiges left upon it of the comparatively smooth internal laminæ of the original bone. They had been removed and discharged in the form of granules, flakes, and scales at a former period, thus leaving the internal surface of what afterwards became the sequestrum, roughened and eroded. In this way it is demonstrable that the osteo-myelitic action has had two distinct epochs in this case. The medullary canal was not filled up, and I could readily introduce my little finger into it.

Periostosis of the stump-bones.

The principal stump-bone (that of the tibia) was found to be very much enlarged by the deposition of successive layers of new bone upon its external laminæ, beneath the periosteum (periostosis). It was fully an inch through its wall from its circumference to the medullary canal. The amount of the enlargement (periostosis) was so great that the tibia and fibula had coalesced, and appeared to constitute but one bone. The new osseous tissue had a reddish color, and a spongy or cancellous structure from the large size of its medullary spaces.

Inflammatory osteo-porosis of stump.

Periosteum inflamed.

That part of the original compact tissue which had not become necrosed, exhibited also a reddish color and a loose, spongy, cancellous structure (inflammatory osteo-porosis).[1] It looked precisely like the new osseous tissue, and no line of separation between them was apparent. The investing periosteum was thicker and redder than natural. The next step in the operation consisted in detaching the soft parts from the club-shaped end of the stump-bone, and excising a considerable part of it with a cutting forceps. The wound was dressed with dry lint.

Microscopical examination of medullary tissue.

On making a microscopical examination of the osseous chips, the soft tissue taken from the medullary spaces, both the deep-seated and the superficial ones, was found to consist of some fat vesicles and an abundance of marrow cells. They were nucleated, not granular, and not uniform in size, some being large and others relatively small. Some of the fat vesicles, when examined next day, contained crystals of margaric acid. The microscopical examination was made by the operator, Dr. Gouley.[2] The history of the case was drawn up by the author from personal examination and observation.

[1] This term, derived from two Greek words, ὀστέον, bone, and πόρος, a pore, signifies a morbidly porous condition of the osseous tissue. The process by which it is generally produced, is synonymous with *medullization*. Definition.

[2] We wish here to remark, once for all, that the microscopical examinations detailed in this chapter, were nearly all conducted by Prof. Gouley. The author, however, assisted at them, and prepared the descriptions thereof at the time they were made.

December 4. — It is reported that the patient is doing well, and that the wound of operation is granulating.

January 12, 1866. — Patient again reported to be doing well.

April 1. — I am informed that the patient has made a good recovery.

Comments. — The fact that the disease, in this case, appears to have had two distinct paroxysms or epochs, has already been sufficiently alluded to. There is, however, another very interesting feature which belongs to it, one that is seldom met with in the stumps of amputated limbs; and that feature is the spontaneous perforation of the bone in its continuity in order to permit the escape of imprisoned pus. This spontaneous trephining of the compact wall of the tibia appears to have occurred several months before the patient presented himself at Dr. Gouley's clinique. In another class of cases, such, for example, as suppurative inflammation of medullary tissue of the long bones occurring spontaneously, the continuity of the limb being at the same time preserved, it not unfrequently happens, provided the inflammatory process has not been very acute in character, that the walls of the diseased bone have one or more holes bored through them by an ulcerative process, to permit the outflow of imprisoned matter. Hey has reported two cases that have already been referred to, wherein this spontaneous perforation, or operation of trephining performed by nature, occurred in the tibia; Stanley one case where it happened in the humerus; and Chassaignac one case where the femur was the bone involved; and the writer has recently seen two dry specimens of such spontaneous perforation occurring near the lower end of the femur, one of which presented itself in the practice of Prof. Carnochan.[1]

Spontaneous perforation of bone.

Chronic osteo-myelitis in stump-bones very often produces *necrosis.* This probably is the tangible result which has most frequently been occasioned by chronic inflammation of the medullary tissue, following after amputation, in the course of the war. The Army Medical Museum at Washington contains a great number of specimens of necrosis having apparently such an origin. Some of them are composed only of the internal lamellæ of the bone, in which case the *necrosis* is called *central;* but others of them embrace the whole thickness of the bone, and in such case the *necrosis* is denominated *total.* Chronic osteo-myelitis produced an internal necrosis in the case upon which we are now commenting, and this dead bone was the source of a great deal of trouble to the

Necrosis as a result of osteo-myelitis.

[1] Pott also reports a case wherein the cranium was perforated spontaneously.

patient. It irritated the surrounding tissues by its presence, and kept up an inflammatory condition, and a damaging suppuration in them. The early removal of the necrosed bone is imperatively demanded in all such cases; and, in general, it should be extracted by the surgeon's art, as soon as its separation from the living bone is complete. If it be left to the operation of nature alone, months, years, and even a lifetime, may pass away, and still the necrosed osseous tissue remain unremoved. Again: we have often seen a stump continue to be irritable, tender, and to discharge purulent matter through a fistulous channel, until the extraction of a small fragment of necrosed bone has been effected by surgical means, when the fistulous channel healed up, and the stump became entirely sound without delay. The subject of necrosis possesses much practical importance, and therefore will be more fully developed in a chapter devoted specially to it.

Great enlargement from periostitis.

Another interesting feature in this case was the great amount of enlargement which the tibia had undergone. This was produced by the deposition of successive layers of new osseous tissue beneath the periosteum from inflammatory excitation of its innermost or osteo-genetic layer, having a reddish color, and a distinctly porous or cancellous structure. It is also worthy of remark that the old bone around which the new osseous development had taken place, which, by the way, belonged originally to the compact tissue of the shaft of the tibia, also had a reddish color and a spongy structure, and looked so much like the new bone that we could not tell where the old bone ended and the new bone began, or, in other words, that there was no line of separation perceptible between them. This abnormal condition of the old compact osseous tissue is called *osteo-porosis*,[1] or *medullization*, and must be looked upon as one of the legitimate consequences of the inflammatory process operating in bone. It consists essentially of an increase in size of the medullary spaces effected at the expense of the hard osseous lamellæ, with a corresponding development of new medullary tissue to fill up the large medullary spaces. The inflammatory osteo-porosis, as well as the hypertrophy in the case now under consideration, resulted directly from the irritation occasioned by the dead bone encased within it.[2]

Osteo-porosis, how produced.

[1] As already stated, this term is derived from two Greek words, ὀστέον, signifying bone, and πόρος, a pore, and denotes an abnormally porous condition of the osseous tissues.

[2] Ollier has found, in experimenting on animals, that traumatic irritation of the marrow is frequently transmitted to the periosteum, and gives rise there to a new bone formation, even more voluminous than would be produced by irritation of the periosteum itself. A very curious result is occasionally observed; the irritation of the marrow may cause sup-

The Causes of Osteo-myelitis. — The etiology of disease is, in general, a subject of great importance in a practical point of view. We cannot expect to remove the causes of disease unless we are acquainted with them. It is only through the aid derived from a thorough appreciation of the causes which may produce any disorder that we can be able to shield the individual man from its attack, especially when he is surrounded by circumstances favoring its occurrence. The medical man who is ignorant of the conditions required for the generation of a particular malady, is, in great measure, powerless to prevent the incursions of that malady. Furthermore, unless he has a good acquaintance with the etiology of the disorder he is called upon to treat, he may commit the sad error of permitting it to be aggravated by the operation of causes or circumstances which are susceptible of removal. We say, then, that the science of etiology, whether viewed in the light of enabling us to prevent the occurrence of certain diseased conditions of the organism altogether, or of assisting us to conduct them to a successful issue after they have appeared, is a matter of the very highest degree of practical importance. He does well who teaches us how to cure a disease, more especially if it be one that is dangerous to life or grievous to bear; but he does still better who shows us how to avoid it entirely. For these reasons the writer proposes to inquire into the causes which have been found to produce inflammation of the medullary tissue of bone, as thoroughly as circumstances will permit in the present state of our knowledge of the subject.

Importance of etiology in general.

The causes which may develop an inflammation of the marrow are susceptible of being divided into two principal classes, namely, the general, and the special or local. Among those which are general or systemic in their operation, we may enumerate the period of youth, the male sex, the occupations in life which exhaust the physical vigor by their laborious nature, and, at the same time, expose the person to traumatic lesions of the medullary tissue, the lymphatic temperament, and all the unsound conditions of the general health, such as those produced by the scrofulous, the syphilitic, and the cancerous cachexiæ, and by the rheumatic, the gouty, and the scorbutic diathesis. Among the causes which are special or local in their operation, we may enumerate the various wounds and injuries of bone, surgical opera-

Classification of causes of osteo-myelitis.

puration of that substance, the bone be completely transformed into a new medullary tissue, while a voluminous formation of fresh bone is developed beneath the periosteum, the bulk of the whole being double what it was before the institution of the experiment. See *American Journal Medical Sciences*, January, 1868, p. 151.

tions involving the osseous tissue, when undertaken for the cure of disease as well as the relief of injury, and severe inflammation or destructive ulceration located in the parts bordering closely upon bone.

Osteo-myelitis is preëminently a Disease of Youth. — A very large majority of its victims have been young people, that is, persons who have not reached the middle period of life. Of seventy-two cases occurring in military practice under the author's observation, the notes of which have been preserved, but five were more than 40 years old. Two of them were 40, one 44, another 48, and the other 49.[1] But the statistics with regard to the age at which osteo-myelitis is most likely to occur, that are derived from this source, may be objected to, on the ground that the field of observation is limited practically to soldiers, nearly all of whom are young, but few of them in our army being less than 18 or more than 40 years of age.

Youth as a cause of osteo-myelitis.

Let us, then, ascertain what the statistics collected from civil practice, against which this objection cannot be urged, teach upon this point.

Of *four* cases of osteo-myelitis observed by Chassaignac, one was 12, another 14, another 16, and the other 32 years old. Neither of them followed a surgical operation, or a solution of the continuity of the bone.

Of *five* cases of this disease observed by Reynaud, one was 16, another 24, another 31, and in the other two the age is not stated. In all of them it followed amputations performed for disease. Four of them were amputations of the thigh, and one of the arm.

Of *two* cases recorded by Hey, one was 15, and the other is described as a young lady.

Of *three* cases seen by Mr. Phillips, one was 17, another 32, and the age of the third is not mentioned.

Of *six* cases recorded by Mr. Stanley, one was 14, another 16, another 70, another is described as a young man, and the age of the remaining case is not stated.

Of *ten* cases which have recently occurred or been treated in the New York, the Bellevue, and the St. Vincent's Hospital, and in private practice in this city, all of which I have seen, the young-

[1] These 72 cases of osteo-myelitis occurring among the wounded, were distributed as follows, in respect to age: Five (5) were 40 years old, or more than that; six (6) were between 35 and 40; thirteen (13) were between 30 and 35; seventeen (17) were between 25 and 30; twenty-four (24) were between 20 and 25; and seven (7) were between 18 and 20. The youngest of these cases was 18, and the oldest 49.

est was 11, and the oldest 46 years of age. But two of them had passed the middle period of life.[1]

Of *thirty-seven* cases of osteo-myelitis, occurring in civil life, and in the practice of a considerable number of surgeons, in both Europe and America, which the writer has either witnessed or collected, but one had reached 70, one 60, two 46, and one 40 years of age, which gives a total of only *five* cases occurring after the age of 40. Of the remaining *thirty-two* cases, *eleven* were less than 20 years old, *eight* between 20 and 30, *four* between 30 and 40, and in *nine* cases the age is not specified. In two of them, however, it is stated that the patients were young. It will be perceived that in *twenty-eight* cases, occurring in civil practice, wherein the age was accurately noted, *twenty-three* were less than 40, and only *five* were more than 40 years of age; or, to state the same matter somewhat differently, *nineteen* were less than 30, and *nine* were over 30 years old. The youngest patient was but 11, and was treated by Professor Van Buren.[2]

Why youth predisposes to osteo-myelitis.

One reason why inflammation of the medullary tissue is more apt to occur in youth than at the later periods of life, is, in all probability, the fact that the bones are still growing, and the marrow, especially in the long bones, is more vascular and more irritable, during the early than during the later years of life.

Sex as a cause.

The influence of *sex* in the production of osteo-myelitis is about as strongly marked as that of age. All of Chassaignac's and all of Stanley's cases occurred in males; and, of thirty-seven cases of that disease occurring in civil practice, twenty-eight were males, only eight were females, and in one case the sex was not stated.

Occupation as a cause.

Occupation appears to promote the occurrence of osteo-myelitis in proportion as it exposes the osseous frame-work of the body to mechanical injury; and hence that disease is frequently met with among machinists, railroad employees, and soldiers, the latter especially in time of war.

[1] Of the *ten* cases which I have recently seen in civil practice, only *two* were more than 30 years old. *One* was 11, *one* 19, *two* 22, *two* 24, *one* 25, *one* 28, and *two* 46 years of age. One of these patients, the child of 11, was met with in private practice. All the others were seen in hospitals. It should also be stated that they were met with, not in hospitals for children, or for children and adults together, but in hospitals devoted to the treatment of adults almost exclusively. This accounts for the comparatively small number of the cases occurring before the age of 20.

[2] Vide Case XLIX.

Scorbutic diathesis as a cause.

Again: the *scorbutic diathesis* probably exerted considerable influence in the production of osteo-myelitis among such of our troops as were tainted with it, throughout the whole war. At least such appears to have been the opinion of many intelligent observers who have paid attention to the subject. This opinion, however, seems to rest on general grounds and impressions, more than upon individual facts and cases. But I think there can be no doubt that, other things being equal, the scorbutic wounded are more apt to become the victims of this disease than the non-scorbutic; and, viewed in this light, scurvy may, with propriety, be considered as an important *predisposing* cause of osteo-myelitis.

Foul air of hospitals as a cause.

We must next give suitable consideration to the subject of *impurity in the air of hospitals as a cause of osteo-myelitis.* I have no doubt that hospital air, so called, exerts an important influence in the production of this disease. I believe that I have seen many cases of inflammation of the medullary tissue occur after injuries and surgical operations involving bone, among patients treated in the wards of both military and civil general hospitals, and prove fatal there, while if the same patients had been treated with precisely the same attention, but in a different atmosphere, such, for example, as that afforded by hospital tents properly pitched, or in the open air itself, or, in civil life, in isolated private dwellings, they would not have got osteo-myelitis at all, or, if they did, it would have presented itself in so mild a form as not to result in death. I can now call to mind several fatal cases of this disease which have recently occurred in hospital practice (civil), when, in all probability, the patients would have recovered if treated with only the same attention, both professional and otherwise, in isolated private dwellings or quarters. Moreover, clinical observation has abundantly shown that if the wounded, and especially the amputated, be subjected to the action of an atmosphere loaded with the effluvia arising from human bodies when aggregated, and with the odors emanating from suppurating wounds, notwithstanding that cleanliness, in the ordinary sense of the word, is maintained, their wounds are very apt to take on an unhealthy action, their stumps to become the seats of a destructive inflammation, which is not confined to the flap, but involves the medullary tissue of the bone also. Even when the hospital ward, and the bedding, and the clothing, and the persons of the patients themselves are all clean, if the air which fills the ward, *i. e.*, the

air which the patients respire, and in which they are constantly immersed, is not clean likewise, they will be exposed to the occurrence of inflammatory mischief in their wounded parts, not excepting the medullary tissue; and in this way the impure air of general hospitals becomes an *exciting* cause of osteo-myelitis of so much importance that it ought not to be overlooked. It is not too much to say, in this place, that the want of a wholesome atmosphere for the inmates of hospitals to breathe constantly both day and night, which results from imperfect or deficient means of ventilation, is one of the most glaring evils which we now meet with in the management of hospitals.

Prof. Fayrer on hospital air as a cause.

It has been thought by some that the hospital air was almost the sole cause of osteo-myelitis among our wounded during the late war. The writer believes that this opinion, while correct to a considerable extent, is by far too exclusive On this subject a recent author, Dr. J. Fayrer, Professor of Surgery in the Medical College at Calcutta, entertains the same belief as the writer. He states that for a long time he attributed the causation of this disease to the bad sanitary condition of the Indian hospitals; but "I am now persuaded that although unfavorable conditions of this character increase the liability, and may, in some instances, determine the occurrence of a disease, which under more favorable circumstances would be absent, yet that these alone are not sufficient to account for a condition which makes its appearance when other cases are doing well, and when other parts of the same wound are perfectly healthy and undergoing vigorous repair. It is not at all unusual to see an amputation in which part of the bone has perished, whilst the soft parts of the stump are healthy, and whilst other surgical cases in the same ward are doing well, the aspect of the cases, generally, in hospital, also being favorable." [1]

Prof. Van Buren on hospital air as a cause.

Professor Van Buren has communicated to the writer some observations which relate to the influence exerted by hospital air in the production of osteo-myelitis. He remarks, "In my experience the chronic form of the disease resulting in necrosis of stump-bones is the rule after hospital amputations, and the exception in private cases. After some thought, I cannot recall a case of the disease which has occurred to me in private practice." This testimony is important.

Other systemic causes.

The remaining causes of inflammation of the marrow, that are *general* in their nature, can be more conveniently considered in connection with the individual cases which

[1] Vide *American Journal Medical Sciences*, January, 1866, p. 251.

tend to illustrate their influence; and, therefore, such a course will, for the most part, be pursued, so far as they are concerned. Prominent among the systemic causes of osteo-myelitis which belong to this category are the scrofulous and the syphilitic dyscrasia and the rheumatic and gouty diathesis.

Special causes of osteo-myelitis.

We will now proceed to the consideration of those causes of osteo-myelitis which are local or special in their operation, and act directly upon the medullary tissue at the place of disease. It may be stated in a general way concerning them, that they are, for the most part, of a traumatic nature, and result directly from violence, or the application of force, in some form or other, to the bones; that they are found to be operative in both the civil and the military life, and are therefore met with in both the civil and the military practice of our art, but much less frequently in the former than in the latter. The civil surgeon will, however, sadly err, if he thinks that a cognizance of the causes which may produce inflammation of the medullary tissue, belongs to the domain of military surgery alone; and if he acts consistently with such a belief in his practice, he will be almost certain to overlook this disease when it presents itself in his patients, although the symptoms indicating its advent may be strongly marked, and such as he would not fail to perceive the meaning of, if his mind were not preoccupied with a false theory.

Mostly traumatic.

Belong to both civil and military surgery.

Contused wounds of bone as a cause.

Proceeding, then, with an account of the traumatic causes of osteo-myelitis, we remark, *in the first place*, that it may be produced by *contused wounds of bone*. This fact was first recognized in civil practice, and was first placed upon record by Percival Pott, in some remarkable observations upon contusions of the cranium. It has also been ascertained among the wounded treated in our army hospitals, that contused wounds of bone are very apt to be followed by inflammation of the medullary tissue; and the following case, which occurred in the author's practice, affords a strongly marked illustration of it, occurring in a long bone.

CASE VI. *Contusion of the Shaft of the Left Femur by a Grazing Bullet; Extravasation of Blood into the Marrow; Suppurative Osteo-myelitis; Extensive Necrosis, Osteo-porosis, and Caries; Pus in the Medullary Canal and Hip-joint; Death on the Fiftieth Day;* reported by Acting Assistant Surgeon Charles H. Osborne, U. S. Army. —

Sergeant F. Waltz, Co. D, 8th Michigan Vols., aged 39, was admitted to the Stanton U. S. Army General Hospital July 4, 1864. He had been wounded in battle before Petersburg, Va., June 30, by a minie ball, which, entering the outer side of the right thigh in the upper third, passed transversely through behind the bone; then, entering the left thigh, passed through it, grazing the femur, and lodged beneath the skin, from whence it was extracted by a small incision. At the time of admission to hospital, both wounds were suppurating freely, and his general condition was poor. Full diet, tonics, and stimulants were ordered, with ice-dressings to the wounds. His bowels being constipated, sal. Rochelle ʒ i. was administered. He complained of pains in the shoulders and upper extremities. His bowels remained obstinately constipated, and required occasionally laxative medicines until August 10, when the opposite condition set in, and he had from three to four passages during the twenty-four hours, attended with rigors. Bismuth and opium were added to the treatment. The tongue became coated, he lost his appetite, and by August 14, all the symptoms commonly pertaining to typhoid disease were fully developed. The treatment now consisted in the administration of nutrients, stimulants, small doses of ol. terebinth. in emulsion, and quiniæ sulph. in solution. The purulent discharge from the wound became more profuse and thin. *He complained of having great pain in the left thigh.* Necrosed bone was detected by examination with a probe. Opium was administered to allay the pain, and the diarrhœa was partially checked by the injection of starch and opium. He gradually sank deeper into the typhoid condition, and died August 19.

Autopsy twenty-four hours after death. Cadaver extremely emaciated; muscles of left thigh infiltrated with pus; femur extensively denuded of its periosteum; necrosis of its shaft for two thirds its length; a new bony deposit surrounds the femur at place of contusion; *the lower three fourths of the medullary canal contain a thin greenish-colored pus*, which empties itself where the bone is denuded; *the upper fourth contains old clotted blood.* Pus to the amount of f. ʒ i. was found within the capsule of the hip-joint.

The lungs and heart were normal; liver slightly enlarged; spleen enlarged and soft; kidneys normal; Peyer's glands presented the "shaved chin" appearance.

The bullet had grazed and bruised the femur a short distance below the trochanters.

The porosity of the diseased and necrosed bone was very much increased. It presented a worm-eaten or honey-comb appearance, which was the most marked in situations where the periosteum had become detached. There was pus in the pores, medullary spaces, or cancelli in such localities.

The author published this case, along with several other examples of

contused wounds of bone, in the "American Journal of the Medical Sciences," for July, 1865.[1]

Comments. — In this case of graze-wound of the femur, the mechanical injury was not confined to the osseous tissue against which the bullet directly impinged, but the medullary tissue also was injured, although the projectile did not come in contact with it; for the autopsy disclosed the fact that a considerable quantity of blood had been extravasated into the medullary canal, at the place of injury, some time before death, and this extravasation of blood does not appear to have been connected with any event in the clinical history of this patient, other than the contused wound of his femur. If that bone had not been injured, the hemorrhage into its marrow would not have taken place. It seems, then, that, in this case, the impulse of the bullet was communicated to the soft marrow, through the compact wall of the bone, and was sufficiently powerful, after reaching the marrow, to lacerate some of its capillary blood-vessels, and thus produce an extravasation of blood in its parenchyma or substance. When a rifle-ball strikes the compact tissue of a bone in the way it did in this case, it throws the osseous lamellæ lying beneath the place of impingement into vibrations, which are propagated through the whole thickness of the bony wall to the contents of the medullary canal. Now, the difference, in respect to density, elasticity, and tenacity, between the osseous and the medullary tissue is very great. Hence it follows that the vibrations produced by the stroke of a bullet upon a bone, which are rhythmical in the bony tissue, are not rhythmical when propagated to the medullary tissue. They jar against each other in the latter, from the disturbance of the rhythm; and in this way the discordant vibrations, especially when they are strong, are apt to rupture some of the delicate capillary vessels with which the marrow is copiously supplied.[2] In this way,

Marrow indirectly injured.

Laceration of capillary blood-vessels of bone.

Vibrations in osseous tissue.

Vibrations not rythmical.

[1] Vide p. 30 etc.

[2] On this topic Pirogoff says, "That which Neudërfer has said of the effects upon the periostum of a projectile, I find very characteristic, and agreeing with my own convictions: 'An elastic bone struck by a projectile is thrown into vibrations of a certain extent and duration, like a tense cord or spring. . . . . If the bone vibrates too rapidly, so that the periosteum and other soft parts cannot follow these vibrations or movements, the membrane becomes detached from the bone.' Whenever a bone injured by a projectile is carefully examined, the following changes, which I consider of the utmost importance, are found in the periosteum and medullary cavity. 1st. Ecchymosis of the periosteum, with or without detachment of that membrane (to be considered in another place, see chapter on *periostitis*); and 2d. Every diaphysis injured by a projectile I have had the opportunity to divide lengthwise, with a saw, has presented the same disseminated or confluent extravasa-

then, an extensive ecchymosis of the marrow appears to have been produced in the case now under consideration. Furthermore, since ecchymosis occasioned by violence is always characteristic of the form of injury called contusion, we may with propriety say that in this case the marrow was *contused;* and, since the bullet did not come into direct contact with the marrow itself, but injured it through the medium of the compact wall of the bone, we can go still further, and say that the *contusion of the marrow was mediate* in its character. Again, if the vibrations produced by the stroke of the projectile had not been sufficiently strong, when propagated to the medullary tissue, to lacerate its vascular net-work, but, at the same time, were sufficiently strong to occasion at least some functional disturbance or some irritation of that tissue, we would say that *concussion of the marrow* had been produced. In the opinion of the writer, if the discordant vibrations occasioned by force suddenly applied to the exterior of a bone are sufficiently powerful to ecchymose the marrow by rupturing its capillary blood-vessels, it is proper to employ the term *contusion* to designate the character of the injury inflicted upon the marrow; but if the discordant vibrations are not sufficiently powerful to produce ecchymosis of the medullary tissue, while, at the same time, they are strong enough to throw it into an irritable condition, a condition wherein it is prone to become inflamed, it is better to use the term *concussion* to represent the nature of the injury sustained by the marrow. While reflecting upon this topic, it should not be forgotten that the medullary tissue, especially in the diaphysis of the long bones, is very much exposed to injuries in the nature of concussion and contusion, on account of a peculiarity in its anatomical structure, which was mentioned while we were speaking of its physiological anatomy, namely, the small amount of connective tissue with which it is supplied. It has no strong fibrous frame-work to protect it against the incursions of violence. The writer has seen several additional cases wherein the marrow was ecchymosed in a long bone, one of which, also produced by a contused wound of the osseous tissue, he published, not long since, in an essay on that kind of injury.[1] The fibula was the bone involved.[2]

Ecchymosis of marrow.

Mediate contusion of marrow.

Concussion of marrow.

Distinction between contusion and concussion.

The writer's experience in ecchymosis of the marrow.

tions [of blood] in the medullary tissue. When the diaphysis is comminuted, the medullary tissue is also crushed and lacerated, ecchymosed, or disorganized, by the fragments driven into the osseous canal." — Pirogoff's *Outlines of General Military Surgery.* Leipsic, 1864.

[1] Vide *American Journal Medical Sciences,* July, 1865, p. 23 *et seq.*

[2] Dr. Allen has reported three cases of suppurative osteo-myelitis following "graze wounds" of the long bones (humerus in one and femur in two instances), in which the

Another feature of this case, which deserves a passing comment in this place, is the fact that the necrosis of the femur did not occur till a very late period in the clinical history of the patient. The osseous tissue had undergone some striking and important changes in its structure and appearance before that event took place. The dense, compact structure of the bone had become changed into a very loose and spongy formation, having a worm-eaten and honey-combed appearance, through which the purulent matter readily found its way from the medullary cavity to the exterior of the bone. Now the greatly increased porosity of the bone (osteo-porosis) and the carious condition which were here found, had been directly produced by an inflammation of the osseous tissue itself (ostitis). We entertain this belief because we are not acquainted with any other agency by which this form of osteo-porosis can be produced. Furthermore, it appears probable that the inflammatory process which attacked the marrow soon after its contusion, spread from it to the osseous tissue, and continued to develop itself there until the supply of blood was cut off from the bone by the destruction of the marrow on the one side, and the detachment of periosteum on the other, when this tissue immediately perished. We say that the inflammatory process in this case originated in the marrow, and spread from it to the contiguous bone, because it was much further advanced in its career of destruction in the former than in the latter, at least so far as their histological elements are concerned. The texture of the former was almost entirely destroyed by the inflammatory process, while that of the latter was but partially so. At the moment when the necrosis occurred, the lower three fourths of the medullary canal were filled with a purulent fluid, the product of the destruction of the marrow by inflammation; but, at the same time, the surrounding osseous tissue had only acquired a highly porous condition through the same agency.

Necrosis occurred late.

Osteo-porosis and caries before necrosis.

From degenerative ostitis.

Inflammation began in the marrow.

With respect to the symptoms, it is worthy of remark that *the patient complained of having great pain in his diseased thigh.* It is also worthy of remark that he did not die of pyæmia, although the osteo-myelitis was very acute in character; that, during life, he did not exhibit the peculiar group of symptoms which characterizes pyæmia, and that, after death, visceral abscesses were not found at the autopsy.

Symptoms.

Pyæmia did not occur.

medullary tissue appears to have been injured in the way of *concussion* only; at least, no mention is made of *ecchymosis* of the marrow as one of the morbid conditions revealed by the autopsy. — *American Journal Medical Sciences*, January, 1865, pp. 44–47.

It also should not be forgotten that the disease invaded the *hip-joint*, and produced *pyarthrosis* there.

The following case presents an example of acute osteo-myelitis of the thigh, produced by a severe blow, in civil life. It occurred in the practice of M. Chassaignac, and the following account of it has been translated from his book.

A case from civil life observed by Chassaignac.

Case VII. *Suppurative Osteo-myelitis (acute) of Right Femur, following a Severe Blow; Purulent Infection; Death; Autopsy; Metastatic Abscess behind Sternum; Spontaneous Perforation of the Wall of the Femur; Medullary Canal enlarged; Deposit of New Osseous Tissue on the Exterior of the Femur, etc.* — Eugene Larnier, aged 32, a jobbing merchant, was admitted to the Lariboisiere Hospital, November 29, 1855.

About six weeks before his admission to hospital, this patient received a violent blow upon his right thigh, near the junction of its inferior and middle thirds. A pretty considerable extravasation took place in that region. The patient, not suspecting the gravity of the injury, neglected to take care of himself. His occupation compelled him to make long excursions; he walked much. At the end of three weeks, an inflammatory trouble became manifest in the diseased limb. It was probably more painful than the patient acknowledged. Then he took to his bed. He did not remain there long, however, on account of the irksomeness of inaction. He resumed his habits of walking, but with more caution. Then he took to his bed anew.

Illustrative case.

Fifteen days were passed in these alternations of repose and exercise. Then the patient, being restless, presented himself for surgical advice, and decided to enter the hospital November 29, 1855.

November 30. — On examining him, the following condition of things was ascertained: considerable swelling of the thigh which terminates abruptly, near the level of its inferior third; pain rather acute, and fluctuation resulting from the effusion. Diagnosis, periostitis, consecutive, probably, to the inflammatory irritation of the place of sanguineous effusion.

December 1. — Double drainage. The liquid which flows away is a mixture of blood and pus. Some hours later, however, it became entirely purulent.

December 2. — Evacuation of a considerable quantity of pus by the perforated tubes.

December 4. — Suppuration more abundant, and coming from the deeper parts of the limb, far beneath the aponeurosis. The articulation of the knee is enormous in size, and distended by the pus which exists in its interior.

December 5. — The disease has made fresh progress; the thigh is more tense; prescribed twelve wet cups upon the knee, and large poultices upon the whole limb.

December 6. — Condition the same ; poultices.

December 7. — Slight improvement ; the place of suppuration empties itself well. Douches and fomentations, which procure great relief for the patient. Immobility of the limb.

December 8. — There is œdema, gas, and purulent diffusion in the thigh ; but his condition is not worse than on the preceding days ; the swelling of the knee-joint is not increased. It is supposed that the articular capsule being ruptured, the liquid which it contains is being infiltrated into the spaces between the muscles. When simple pressure is made upon the soft parts, the pain is not acute ; but when the limb is grasped with the whole hand or with both hands in order to ascertain the condition of the deep parts, the patient raises a cry. Although the course of the disease has not been clearly that of osteo-myelitis, still its presence cannot now be doubted. Three large incisions were made in the outer part of the thigh ; by means of these incisions, the pus situated in the neighborhood of the bone was evacuated ; it was ascertained that the latter was not despoiled of its periosteum.

December 9. — A new incision at the inner part of the thigh. Communication was established by means of drainage tubes between this opening and that which had been made the day before. Amputation was proposed to the patient, but he rejected it with emphasis.

December 11. — A new incision at the inner part of the leg below the articulation of the knee. Issue of pus coming from the joint. Fever ; erysipelas of the thigh.

December 12. — Condition the same ; the erysipelas has not progressed ; knee very tense ; the deep parts of the limb appear to be full of pus. Diarrhœa.

December 15. — The suppuration seems to diminish ; but the diarrhœa does not stop, and hiccough has supervened. Fomentations, diascordium, and aconite.

December 16. — Extreme feebleness ; considerable alteration of the features ; continuation of hiccough.

December 18. — The patient appears to be worn out by the profuseness of the suppuration ; face livid ; the diarrhœa and the hiccough persistent.

December 19. — Died at two o'clock in the morning.

Autopsy. — Liver, spleen, and lungs perfectly healthy ; large clots in the cavities of the heart. The head was not examined. Metastatic abscess behind the sternum.

Autopsy.

Both the tibio-femoral and coxo-femoral articulations contain pus, especially the first.

Considerable thickening of the right femur in the inferior third ; the thickened strata of osseous tissue are newly formed. The periosteum is loosened only in a very limited space, at which a perforation is established leading from the interior of the medullary canal to the exterior

of the bone. The inferior half of the medullary canal is considerably enlarged and full of pus in a semi-concrete or semi-liquid state. The portion of the canal which is occupied by the pus is separated from the superior half by a complete osseous obturation of the medullary canal. A membrane that is thickened and injected envelops the purulent collection, wherein the microscope discovers nothing besides pus globules, fibrine, and fat.[1]

Comments. — After what has been said in our remarks upon the preceding case, concerning *concussion and contusion of the marrow*, it does not seem to be necessary to make any comments here upon the influence which they doubtless had in the production of osteo-myelitis in this case. We will therefore proceed to consider briefly the other points of interest which it presents. Comments.

Firstly, the patient received a severe blow upon his thigh which was followed by considerable extravasation, and, neglecting to take care of himself, was attacked with suppurative inflammation of the medullary tissue. It is probable that if either he or his attendants had recognized the possibility of the supervention of so grave a disorder upon this kind of injury of the thigh, and had endeavored to prevent it by appropriate treatment, such as absolute quietude, the local abstraction of blood by cups or leeches, the application of discutient lotions, and the internal administration of iodide of potassium, he would have entirely escaped from having the disorder in a suppurative form; and this conclusion is rendered still more probable by the fact that in the early part of his sickness he was always benefited for keeping his bed for even a little time, and by the other fact that notwithstanding the small amount of care he took of himself, a period of about six weeks elapsed before he was compelled to enter the hospital. Viewed in the light which is thrown upon them by this case, contusions of the thigh do not appear to be injuries which are unworthy of the surgeon's attention and solicitude. By attending to them promptly in the outset, a life may not unfrequently be saved. By failing to recognize their importance until suppurative osteo-myelitis has supervened, a life may not unfrequently be sacrificed which otherwise might have been saved. Suppurative osteo-myelitis from blow on thigh. Contusions of thigh.

In the next place, it was found at the autopsy that Nature had made strenuous efforts to limit the mischief occasioned by the suppuration of the marrow. She had plugged up the Nature's efforts at limitation.

[1] Vide *Traité Pratique de la Suppuration*, etc., par E. Chassaignac, tome i. pp. 484, 485. Paris, 1859.

medullary tube with a stopper of new bone, and she had also perforated the wall of the diseased part of the femur for the purpose of allowing the imprisoned purulent matter to escape.

Spontaneous trephining.

With regard to the treatment which might have saved this man's life, after the marrow had suppurated, and before pyarthrosis had occurred, it is possible that, if the indication afforded by Nature in perforating the bone had been promptly followed by trephining it, and removing all the diseased tissue from its interior, the patient might have recovered.

Amputation of the thigh in its upper part was, however, the surgical expedient which was clearly demanded, and probably would have proved successful if seasonably performed, since the disease of the medullary tissue does not appear to have extended above the place of occlusion in the middle of the femur.

After suppuration of the hip-joint occurred, it is not probable that any of the resources of the surgical art would have availed to save this patient.

The next case is believed to have been an example of chronic osteo-myelitis of the cranium, produced by *contusion*, but not accompanied by any original solution in the continuity of the scalp. It was reported by that sagacious surgeon and acute observer, Percival Pott.

Case from Pott.

Case VIII. *Chronic Osteo-myelitis of the Right Parietal Bone, produced by Contusion; Extensive Exfoliation of that Bone; Recovery.* — In the middle of September, 1763, a woman, about 60 years old, fell down stairs backwards. She was stunned with the blow which her head received from one of the steps, and lay senseless some time.

Contusion of cranium.

There was neither wound nor considerable bruise; she was let blood, and kept quiet for some days; at the end of which, finding no inconvenience, either general or particular, she ceased to regard it.

Symptoms.

On the 18th of December, she was taken into the hospital for a swelling on the right side of her head, nearly of the size of a split Seville orange. This tumor, she said, had been preceded by a severe headache without fever; but as she then did not believe that her fall had any share in the production of her present complaint, she said nothing about it.

Sequelæ.

Her head having been shaved, the tumor appeared full of fluid. I divided the scalp, and let out a quantity of greasy, offensive matter. Upon further examination, the bone was found to be

Operation.

bare and carious. I removed such a portion of the scalp as brought the whole into view. The natural texture of the bone was destroyed, and in it were several holes, through which a probe might easily be passed, and from which matter was discharged in such manner, and with such motion, as plainly proved that it came from within the skull. Condition of bone.

She remained in the hospital until the middle of March, during which time no alteration appeared in any part of the bare bone.

The affairs of her family now required her to be at home. She was in perfect good health; was discharged from the hospital; and, as she lived very near to me, one of my young gentlemen undertook to take care of her. On the 28th of March, 1764, a small part of the bare bone came away, and left the dura mater covered by a healthy incarnation; and on the 12th of April following, the whole remainder, being about a third part of the parietal bone, did the same. From first to last she had no kind of uneasiness, and the sore healed without any trouble.[1] Part of parietal bone exfoliated.

Comments. — This case has been introduced here because, in the first place, it occurred in civil practice, and, in the second place, it was reported by one of the most remarkable of all the clinical observers who have ever lived. A spontaneous perforation of the cranium occurred, which undoubtedly saved the patient from much distress and danger. The *puffy tumor* of the scalp was considerably exaggerated by the presence of pus which had come into it through the perforation of the cranium. The narrative of the whole case is very clear, and we shall therefore submit it without further comment. Puffy tumor of scalp.

The following case, related by Assistant Surgeon H. Allen, U. S. Army, is very interesting, and seems to afford an example of inflammation of the diploe produced by contusion of the cranium, from a gunshot, a kind of wound which was not unfrequently met with during the war. A case by Dr. Allen.

Case IX. *Contused Wound of the Frontal Bone, occasioned by a Gunshot; Death on the Nineteenth Day; Autopsy; the Diploe had a dark Yellowish-gray Color at the Place of Contusion; Abscess of the Brain beneath the Place of Contusion.* — Ethan A. Crane, musician, Co. K, 44th New York, was admitted to Carver Hospital for a gunshot glance wound over right side of os frontis, having been wounded at the battle of Cold Harbor, June 3. It appeared to be a flesh wound; the bone was barely bruised. He did very well until June 20, when, to the surprise of his medical attendant, severe cephalic symptoms came on. He be- Gunshot contusion of cranium.

[1] Vide Pott's *Chirurgical Works*, vol. i. p. 125 *et seq.* London, 1779.

came comatose within eight hours, and died on the second day after the appearance of the first untoward symptom. The autopsy revealed a large abscess in the anterior lobe of the right side of the cerebrum, with meningitis. When the calvarium was examined, the external table was found to be perfectly healthy, while the internal presented a very faint attempt at the formation of the circumscribed area. The thickness of the skull was not impaired. When the affected spot was sawn through from above downwards, the *diploe* was found to be of a *dark yellowish-gray color*, having precisely the same appearances which are seen under somewhat similar circumstances at the heads of long bones. Dr. Allen remarks that it may be said that this discoloration was due to local death, since it was found only at the spot where necrosis would in all probability have been discovered. But necrosis could scarcely have shown itself in so short a time, the patient dying on the nineteenth day after the reception of the injury; and from the condition of the diploe, it had evidently been discolored for some days.[1]

Death by central abscess and meningitis.

Inflammation of diploe.

Dr. Allen's remarks.

Comments. — It may also be remarked that the alteration of the color of the diploe, described above, was, in all probability, not produced by necrosis, because the external table of the skull was found to be perfectly healthy at the post-mortem examination. Of course, the "puffy tumor" of Pott had not yet appeared. There is but little doubt in the mind of the author that the dark yellowish-gray color which the medullary tissue of the cranium was found to possess at the place of contusion, in this case, was due to the presence of pus corpuscles; for what cause other than suppurative inflammation could, under the circumstances, have produced this peculiar discoloration? Gangrene appears to be out of the question. It also should not be forgotten, while reflecting upon this case, that death was occasioned by abscess of the brain with meningitis, and that the patient was stricken down by that instrumentality before the inflammation of the diploe had had sufficient time to produce, in full, its destructive effects upon the surrounding osseous tissue. The necrosis of the inner table of the skull was just commencing at the time of the patient's death. In a few days more it is not improbable that necrosis of the external table of the skull would also have taken place, and then the puffy tumor of the scalp at the place of necrosis would not have been slow to appear. As it was, the suppurative inflammation of the diploe, produced originally by the contusion, seemed about to begin its attack upon the integrity of the neighboring osseous tissue.

[1] Vide *American Journal Medical Sciences*, January, 1865, p. 48.

In the *second* place, osteo-myelitis is not unfrequently produced in the long bones by *compound fracture of those bones.* Two examples, both of which occurred in military practice, and were occasioned by gunshot fracture of the femur, have already been related in this essay.[1]

Gunshot fracture as a cause of osteo-myelitis.

The next case is an example of suppurative osteo-myelitis produced by gunshot fracture of the thigh, and occurred in civil life.

Case X. *Fracture of the Femur, occasioned by Firearms; he did well for more than Two Months; Pyæmia finally supervened, of which he died on the Ninety-ninth Day; Autopsy; Osteo-myelitis of Femur and Os Innominatum; Pyarthrosis of Hip; Secondary Abscesses in both Lungs and Sero-purulent Effusion in both Pleural Cavities;* reported by Dr. Edward Farrell, House Surgeon at Bellevue Hospital. — David Suffern, aged 46, was admitted to Bellevue Hospital, September 28, 1865. A charge of slugs had been fired into his thigh on the previous night. The soft parts were wounded in different places, and the femur was broken about its middle. The upper fragment had pierced the muscles, and its sharp end was felt immediately beneath the integument. The fracture was reduced, and Buck's apparatus immediately applied; amount of extension twelve pounds. He was kept in the apparatus eight weeks, and at the end of that time it was found that union had not taken place. His general health was good. The discharge from the wound was healthy, but not profuse. On examination at this time, a loose piece of dead bone was discovered lying at the bottom of the wound. It was extracted by a surgical operation. The limb was then placed betweed sand-bags, and about four pounds of extension applied to keep it steady. He continued to do well for a time. Then the granulations in the wound became pale, although the discharge of purulent matter continued healthy. His general health also began to fail, his appetite diminished, and he complained of feeling weak. About twenty days after the necrosed bone was removed, the patient had a severe chill, and from that time he gradually sank. He had irregular chills, followed by sweatings, every day. His skin became yellow; he also got diarrhœa, and, in a short time, sank into a typhoid condition. He died January 4, 1866.

Case treated in Bellevue Hospital.

Dead bone removed.

Severe chill and death.

Autopsy ten hours after death.[2] Each pleural cavity contained a quantity of sero-purulent effusion, and each lung a number of abscesses. The hip-joint was filled with pus, and there were abscesses in the soft parts around it. The ends of the broken bone overlapped each other about an inch at the place of fracture. They did not lie in apposition, but were connected together by a bridge of new bone, two and one fourth inches in width, two and three

Autopsy.

Bones imperfectly united.

[1] Vide Cases III. and IV. [2] The account of the autopsy was written by the author.

fourths inches in length, and about three fourths of an inch through in its thickest part. The broken end of the inferior moiety was rounded off somewhat irregularly. A considerable quantity of new osseous tissue had been deposited upon the exterior of this moiety, especially at its upper part.[1] This new osseous formation had a reddish color and a porous structure. The medullary canal at the fractured end of this moiety was closed by a new osseous growth having a reddish hue and a very spongy structure. On splitting the bone lengthwise with a saw, a small fragment of the old bone was found lying in the medullary canal, one and one half inches from the end, where it had been thrust by the projectile. There was also a triangularly shaped hole through the compact wall of the bone one inch from its fractured end.[2] The medullary tissue had a red color and a firm consistence. It had become carnified by the inflammatory process. This tough, red, inflamed marrow, when examined with the microscope, was found to consist of a multitude of highly granular marrow cells, which looked very much like pus-corpuscles, with some fat vesicles and spindle-shaped fibre cells. Capillary blood-vessels were also seen here and there, together with some free oil.

Fragment in medullary canal.

At about the junction of the shaft with the inferior epiphysis, a light, buff-colored spot or island, having an irregular shape, was found on the surface of the section. It was a commencing slough. Some of the cancelli in the midst of this island were very large, and contained a very tough yellowish-white substance, looking not unlike fibrine. Examined with the microscope, this sloughing marrow was found to consist of a large proportion of granular matter, a good deal of free oil, a few fibres of connective tissue, and long spindle-shaped fibre cells. No blood-vessels and no fat vesicles were found in it after a thorough examination. Some intensely granular marrow-cells were met with in the margin of the slough, where it bordered upon the red marrow. The granular cells and the fibres of the connective tissue did not become visible in the slough until the pieces under examination were treated with acetic acid.

Commencing slough.

The fractured end of the superior moiety was very irregular in shape. The medullary canal was but partially occluded. There was a considerable quantity of red, porous, new bone (periostosis) deposited upon the exterior of this fragment in the neighborhood of its fractured end. The periosteum covering the bone was generally redder than natural, thickened and loosened, but not completely detached. The circumferential laminæ underneath it were somewhat redder than natural, presenting a rosy hue with minute points of injection; and the longitudinal grooves were considerably deepened and widened. After splitting this moiety lengthwise with a saw, and cleaning off the bone dust, its medullary cavity was seen to be the seat of an extensive suppuration.[3] Not only did the medullary tube contain a large quantity

Pus in medullary cavity.

[1] Vide Plate I. [2] Vide Plate I. [3] Vide Plate II.

of purulent matter, but the suppuration had also invaded the cancellous tissue of the head of the bone, and pus-corpuscles were found in the cancelli, which are situated directly beneath the articular lamellæ. The medullary tube also contained some brownish-colored tissue having a very tough consistence, which was found, on examining it with the microscope, to consist of granular marrow cells, fat vesicles, connective tissue more abundant in quantity than usual, capillary blood-vessels, and free oil. The abscesses contained pus-corpuscles, granular matter, and free oil, but no fat vesicles. The cancelli of the head of the bone, *i. e.*, the light-colored ones, contained pus-corpuscles, granular matter, and free oil. This obtained also with the pale-colored cancelli bordering upon the articular lamellæ. The synovial fringes of the hip-joint were redder than natural. The cartilage of incrustation was not eroded, and did not, as a whole, exhibit any alteration in color visible to the eye, although the joint had been filled with pus. At several points, however, it was perforated by little red-colored holes, about one tenth of an inch in diameter, having sharply defined margins, and looking as if they might have been made with a punch. The cancelli beneath them were suppurating. The cartilage-corpuscles belonging to the cartillage of incrustation were intensely granular and cloudy, so much so as to conceal their nuclei to very great extent.

Cartilage of incrustation.

The cartilage lining the acetabulum was diseased, and the cancelli beneath it were suppurating (osteo-myelitis of os innominatum).

Comments. — The medullary tissue of the upper fragment of this broken femur presented a very strong contrast in appearance, when compared with the lower fragment. In the former the inflammatory process had advanced much further in its career of destruction than it had done in the latter. The marrow was suppurating in the upper fragment, while it was only hepatized in the lower one. The cancelli of the head of the bone contained pus, while those of the condyles did not; and the hip-joint was suppurating, while the knee-joint was sound. This group of facts seems to indicate pretty clearly that, in this case, the osteo-myelitis had a much stronger tendency to spread towards the trunk than in an opposite direction.

Contrast between upper and lower fragment.

Again, the microscopical examination assured us, that, in the head of the bone, many of the cancelli which lie next to the articular lamella, contained pus, and must therefore be considered as foci of suppuration. It should also be remembered that the cancelli are not shut sacks, but that they communicate freely with each other. Furthermore, the cartilage of incrustation was pierced with several small reddish holes, which looked as if they might have been made with a punch. The cancelli be-

Perforation of cartilage of incrustation.

neath them were suppurating. It is not improbable that the inflammatory process which produced the pus in the cancelli, also perforated the cartilage by ulceration, and that, in this way, purulent matter escaped into the hip-joint, and kindled a suppurative inflammation there.

Symptoms preceding pyæmia.

One feature in the clinical history of this case is especially important in a practical point of view, and it is the following: The granulations in the wound became pale and flabby, the patient himself became pale and lost flesh, and he complained of failing appetite and failing strength, before any of the symptoms peculiar to pyæmia made their appearance. At the same time the purulent matter discharged from his thigh "continued healthy." In other words, the general health of this patient was declining, without there being any sufficient cause for it perceptible, either in the condition of the soft parts, or of the internal organs (viscera). It was therefore conjectured that the real source of the difficulty was osteo-myelitis of the broken bone, and an unfavorable prognosis was expressed on that account.

It is also probable that one reason why this patient did not complain more of pain in connection of the suppurative osteo-myelitis, was because the pus could readily flow out from the medullary canal into the track of the wound; for we found at the autopsy that the medullary tube wherein the marrow was suppurating, was not sealed up with a new bony formation.

The author saw this man about the middle of December, through the politeness of Professor Hamilton, in whose service he then was; but he had not been under the care of Professor Hamilton from the beginning of the treatment.

The next case likewise occurred in civil life, and affords an example of inflammation of the medullary tissue of the femur, connected with a compound fracture of that bone, produced by a railroad injury, the thigh having been caught between two railroad cars.

CASE XI. *Compound Fracture of Right Thigh; Arthritis of Knee; Osteo-myelitis of Femur; Severe Irritative Fever; Sacral Bed-sore; Death; Autopsy;* reported by Dr. Owen Ward, Resident Surgeon of St. Vincent's Hospital. — Michael Stack, aged 25, got caught between the cow-catcher of a railroad engine and a car, in consequence of which he

Fracture of Femur.

sustained a compound fracture of his right femur, a little below the junction of its inferior and middle thirds, November 7, 1865. He was admitted to St. Vincent's Hospital November 14. At

that time there was a good deal of swelling about the knee, but not much in the thigh. About two weeks afterwards the thigh also became swelled, and the tumefaction was accompanied by the burrowing of pus in it. He also had fever, which was irritative in type. About the 1st of December he got a bed-sore over the sacrum. About the middle of December he became icterode, and at the same time was much debilitated. On the 7th or 8th day of January, 1866, he began to fail very rapidly, and died on the 12th at two o'clock, P. M. He had very acute pain throughout, which he always referred to the knee. The pain was constant, both day and night. He did not have chills, nor vomiting, nor diarrhœa.

Autopsy twenty-four hours after death.[1] Cadaver much emaciated; right thigh, knee, and leg much larger than the left ones; the femur is fractured a little below the junction of the middle and inferior thirds; an abscess surrounds the bone at the place of fracture; the pus has burrowed very extensively among the muscles of the thigh, both upwards and downwards; the purulent burrowing also extends through the popliteal space far down in the leg; the ends of the fractured pieces are irregularly rounded off, and do not exhibit the evidences of any attempt at union; in the cavity surrounding the place of fracture, three detached fragments of necrosed bone were found, which had obviously been exfoliated from the fractured ends; they are not fracture splinters, but necrosis fragments; externally, where the periosteum formerly covered them, they are smooth, but internally they present an eroded, worm-eaten appearance, produced by the process which separated them from the living bone; at their thick and blunt ends they present the usual appearance of broken bone, and show that, in the first instance, the fracture was nearly transverse and without comminution. The periosteum investing the lower half of the superior fragment is moderately reddened, thickened, and loosened in its adhesion to the bone. The circumferential laminæ of the bone are slightly tinged with red, and the longitudinal grooves are larger than natural in the same locality. There is a considerable deposit of new reddish-colored osseous tissue about the lower end of the same fragment. At one point this periostosis reaches the height of three inches above the seat of fracture. There is a considerable deposit of new osseous tissue in the medullary canal, but not enough to occlude it. This endostosis extends two and one half inches above the place of fracture. The marrow at the end of this fragment presents a blackish color, and appears to be sphacelated, and the sphacelation extends up the canal about half an inch. Above this sloughing marrow the medullary tissue has a yellowish-red color for two and one half inches; above that it is bright-red; and as we proceed upwards, the color gradually deepens, until it finally becomes brown. The

Autopsy.

Necrosed fragments.

Marrow sphacelated.

[1] The account of the autopsy was prepared by the author.

consistence of the red marrow is somewhat greater than natural; but the sclerosis is here not so strongly marked as we have seen it in many other specimens. The cancellous tissue of the head, neck, trochanter major, and, indeed, of the whole superior epiphysis, presents a deep-red color. The cancelli are large and very distinct. The compact tissue of the lower half or three fourths of the diaphysis appears to be denser than natural (condensed), and seems to saw harder than natural. The compact tissue, or rather the surface exposed by its section, is freckled with small irregular-shaped red spots, which are more numerous about the lower part of the superior fragment than elsewhere.[1]

Red spots in compact tissue.

The upper end of the lower fragment is rounded off, not regularly, but obliquely, from behind forwards. It sawed harder than natural. There is also a deposit of some new reddish-colored bone about the upper part of this fragment. Here the periosteum is redder and thicker than natural. The fractured end of this fragment is not sealed up. The marrow, as seen on the surface of a section of this fragment, has a light-red color, shaded here and there with a yellowish tinge. The knee-joint is much stiffened (nearly immovable), and undergoing anchylosis. The cartilage of incrustation has almost entirely disappeared from the condyles of the femur, the head of the tibia, and the patella; and its place is supplied by a thick layer of red, firm, granulations of bone. In this way the head of the tibia and the patella are becoming fastened to the femur. It was these adhesions which made the knee-joint stiff; and if their development had been a little further advanced, there would have been no motion whatever at the knee. The central part of the under surface of the patella was found to present a remarkably bright red color, on detaching it from the condyles of the femur. The medullary tissue of the patella, as shown on the surface of a vertical section, is red.[2]

Medulla of patella red.

The tibia was denuded of periosteum here and there, especially on its back side, for a long distance below the knee, occasioned, apparently, by the burrowing of the pus downwards. The marrow of the tibia had a pale-red, varied in some places with a yellowish-red color.

There were no visceral abscesses. The liver and kidneys had a light-buff color. The spleen and other internal organs were sound.

The lymphatic glands at the groin were considerably enlarged, and redder than natural.

The veins were not diseased.

The adhesions in the knee-joint were taking place by strong, firm (sclerosed), red granulations, which, at many points, were already converted into young bone.

The writer saw this patient several times through the politeness of Prof. Gouley, in whose service he then was.

[1] Vide Plate III. [2] Vide Plate IV.

Comments. — In many respects there is a good deal of similarity between the injuries inflicted by gunshot projectiles and those occasioned by railway carriages and engines. In both of these classes the momentum of the body which produces the injury is very great; and in consequence of it the soft parts are liable to be extensively lacerated and bruised, and the bones to be, not only broken in two, but also split and shattered, and crushed into many fragments. Nor does the similarity end here; for in respect to concussion and contusion of the osseous and medullary tissues, the railroad injuries also bear a strong resemblance to those produced by gunshot projectiles. In both alike the blow is sudden, and comes with great force. The pathological phenomena are essentially the same, whether one of the limbs be crushed off by a cannon-ball or a railroad engine; and, in cases of compound fracture of the long bones, so far as the obstacles to recovery are concerned, it matters little whether the injury be produced by the stroke of a bullet or of a railway machine. Hence it is that inflammation of the medullary tissue not unfrequently results from the concussion, contusion, and laceration of that tissue which accompany railway disasters as well as gunshot injuries.

Comparison of railroad and gunshot injuries.

Again, railroad injuries should, for the most part, be treated on the same general principles as gunshot injuries involving the same parts to the same extent. For example, if the nature of the lesion be such as to require amputation, that operation should be performed during the primary period, and immediately, or as soon after the occurrence of the lesion as practicable. In the case just related, primary amputation of the thigh would have afforded the best possible chance for recovery, and the performance of that operation was demanded by true conservatism in surgery, or that conservatism which sets a higher value on the patient's life than on his limb. Indeed, the prospect of preserving the injured limb must have been very small from the outset; for the fracture was compound, and located within the inferior third of the femur, while the neighboring soft parts and the knee-joint were also much bruised and wrenched. The operation should also have been performed high up in the thigh, in order to get above the injury done to muscle, and bone, and marrow, in the nature of concussion and contusion.

Period for amputation.

With regard to pain as a symptom in this case, it will be remembered that the patient always referred the whole of it to his knee, and appeared to suffer very much in consequence of it. His knee-joint was inflamed. But Köllicker mentions

Pain in the knee.

an anatomical fact of some value in this connection, namely, the nerves of the osseous system are most numerous at the articular extremities of the bones, especially at the knee.[1] This anatomical fact affords a satisfactory explanation of the special intensity of the pain which generally accompanies arthritis at the knee.

Furthermore, it is possible that the severity of the knee-pain led the patient to overlook any less intense pain which may have occurred in the medullary canal of his femur at the same time, and which would have attracted his attention in the absence of the great pain in the joint.

The next case is an instance of chronic osteo-myelitis following gunshot fracture of the femur, and occurred in the author's military practice. It is believed to furnish an illustration of what happened not unfrequently in cases of gunshot fracture of the thigh, which eventuated in recovery, more or less complete, without amputation, during the war.

Case XII. *Gunshot Fracture of Right Femur; Exfoliation of Necrosed Bone in Fragments; Necrosis connected probably with Chronic Osteo-myelitis; Recovery.* — Private John Zane, Co. A, 25th Ohio Vols., aged 28 years, was admitted to the Stanton U. S. Army General Hospital, June 15, 1863. He stated that he had been wounded, May 3, at the battle of Chancellorsville, by a minie ball, which entered the antero-inner side of the right thigh, and passed obliquely through, fracturing the femur in its middle third, and lodged under the integument of the opposite side of the limb, from which situation it was extracted by counter-incision. When he was brought to the hospital, the limb was in a common fracture-box. The wounds were suppurating freely; but the swelling of the thigh and the inflammation were moderate. His general condition was good. The following method of treatment was employed: the limb was placed in Hodgen's apparatus, water dressings were applied to the wounds, and he was allowed two pints of porter daily, together with a full diet. Under this treatment he did well.

June 25. — The lymphatic glands of the groin are swelled and painful; ordered frictions of the part to be made with ol. camphoratum.

August 1. — He continues to do well. The bone has united. The wounds, however, are still open and suppurating; and some small pieces of bone have come away with the discharges.

August 15. — The splint was removed.

September 1. — He gets up and goes about on crutches; but the wounds are not yet healed, and necrosed bone can be felt at the bottom of the sinus on exploration with a probe.

Necrosed bone.

October 1. — Have removed several fragments of necrosed bone from the wound.

[1] Vide Kölliker's *Microscopical Anatomy*, p. 185. London, 1860.

November 15. — Removed several more fragments of necrosed bone.

December 28. — There is at the place of fracture an abundant deposit of what appears to be provisional callus, located mostly on the outer side of the bone, which gives the limb a somewhat bowed appearance, especially when viewed from the front. The anterior orifice of the wound is not yet completely closed; and a small sinus leads from it down to the bone, a portion of which is necrosed, but this fragment is not yet loosened. He is gradually recovering the use of his limb, and can now walk about with the aid of a cane only. By measurement the amount of shortening was found to be two inches.

He was discharged from the service on this day.

In the *third* place, osteo-myelitis has not unfrequently been produced by the *operation of resection, or excision of a portion of bone.* It has been known to follow excision of the elbow-joint, resection of the shoulder and the hip-joints, and the same operation performed in the continuity of the long bones, as, for example, the tibia, the fibula, the femur, and the humerus. According to the author's experience, it is more apt to follow resections in the continuity of the long bones than excisions of their epiphyses. Thus, in four cases of resection in the continuity of the humerus, two had acute osteo-myelitis and died, one had this disease and survived it with much difficulty, and the remaining one escaped it altogether. In five cases of resection in the continuity of the fibula, the tibia being uninjured, only one patient recovered. It is certain that destructive inflammation of the medullary tissue does not follow resection of the shoulder-joint or excision of the elbow-joint with anything like the frequency which is mentioned above in connection with the diaphysis of the humerus and of the fibula.

Osteo-myelitis from resection and excision.

The following case affords an example of osteo-myelitis of the humerus following exsection of the fragments of the shaft of that bone produced by gunshot fracture. It was observed in the author's practice.

Case XIII. *Suppurative Osteo-myelitis (acute) following Resection of Right Humerus in its Continuity for Gunshot Fracture; Death Thirteen Days after the Operation from Pyæmia; Secondary Abscesses of Lungs and Liver.* — Walker C. Welch, private, Co. E, 184th Penn. Vols., aged 22, was admitted into the Stanton U. S. Army General Hospital, July 1, 1864. He stated that he had been wounded nine days previously (June 22), in front of Petersburg, Va., sustaining a gunshot fracture of the right arm in its middle third, and that an operation was performed for it the same day on the field, the particulars whereof he

was not able to give us. The patient also said he took chloroform, and was in good condition at the time of the operation.

On examining him, we found that about two inches of the fractured humerus had been exsected; that the incision of the soft parts was about four inches in length, and made along the outer edge of the biceps muscle. The wound was suppurating. The arm was painful. It was also much swelled and inflamed. The patient was becoming debilitated. Ordered the ice-dressing to be applied to his arm, and nutrients, tonics, and stimulants to be taken internally.

Exsection in shaft.

July 3. — He had parenchymatous hemorrhage from the wound to the amount of about f. ʒviii.

July 5. — He died of pyæmia.

Autopsy. — On cutting open the arm, its tissues were found to be extensively infiltrated with pus. The fractured ends of the humerus were denuded of periosteum, and necrosed. Both fragments of the humerus, on making a longitudinal section of them, exhibited the medullary tissue in an inflamed and suppurating condition. The deposition of pus in the marrow was extensive, but it did not invade the epiphyses.

Secondary abscesses were found in the lungs and the liver. The condition of the veins of the arm was not noted. It is therefore not positively known whether thrombosis occurred in this case, although the clinical history and the morbid conditions revealed at the autopsy make it extremely probable that certain veins of the arm were obstructed with coagulated blood (thrombus).

Secondary abscesses.

In the *fourth* place, osteo-myelitis is very often produced by *amputation.*

Caused by amputation.

Cases I. and II. and V. were examples of it, that occurred in military practice, in consequence of amputation, and many similar examples will be presented in other portions of this essay.

The following case recently occurred in civil practice at Bellevue Hospital: —

Case XIV. *Amputation of Left Arm for Disease of Elbow-joint, followed by Osteo-myelitis; Death from Pyæmia on the Seventh Day after the Operation; Autopsy; Marrow in Stump-bone carnified; Secondary Abscesses in Both Lungs;* reported by Dr. Edward Farrell, House Surgeon at Bellevue Hospital. — Wm. Dargen, aged 28, was admitted to Bellevue Hospital, December 22, 1865, in the service of Professor Hamilton, suffering from an extensively carious condition of the elbow-joint. Abscesses had formed around the joint, and had been extensively incised. The disease commenced about five months before admission to the hospital, and was of a traumatic origin. He had received a blow or a contusion on the joint, from the recoil of a cannon, at that

time. After he had remained in the hospital a short time, it was deemed advisable to excise the carious joint; and, accordingly, Professor Hamilton proceeded to perform that operation; but on dividing the radius, he observed that *pus flowed out of its medullary canal*, and on dividing it again, at a lower point, the same phenomenon was observed. The operation of excision was therefore suspended, and the arm was amputated, at about its middle, by the double-flap method, in its stead. The medullary substance in the humerus, at the place of amputation, was observed to be very soft, and some of it flowed out from the end of the bone, but did not present any other morbid appearance.

Pus in medullary canal.

The patient reacted well, but perspired profusely during the night after the operation. He began to have severe chills on the next day, and afterwards continued to have them at irregular intervals. He perspired freely all the time. He grew worse day by day, and finally died on the seventh day after the operation. The discharge from the stump was unhealthy in character, and there was no attempt at union. He never complained of any pain whatever in the stump.

Death on seventh day.

Autopsy.[1] — Small abscesses were found in both lungs, and some newly formed lymph on the surface of the left lung, with a quantity of sero-purulent fluid in that pleural cavity.

Secondary abscesses.

The lower end of the stump-bone was denuded of periosteum. In one place the denudation extended one and one half inches above the sawn extremity. The detached periosteum was redder and thicker than natural. There were no new osseous formations. The uncovered bone (denuded) was dry, and had a dirty-white color slightly tinged with yellow. It was obviously necrosed, but the line of separation was not yet visible. The marrow protruded somewhat from the medullary canal at the sawn end of the bone, and looked like a mass of dark-red granulations. It was also separated from the medullary tube to about the same extent as the periosteum. On splitting the bone lengthwise with a saw, the marrow was seen to have a dark-red or reddish-brown color for a little distance within the canal.[2] This granulation tissue was very firm and flesh-like in consistence. Above it the marrow had a coppery-red color, but it was also very firm and flesh-like in consistence (hepatized), a fact which was observed both by Professor Van Buren and myself. Its consistence was so great as to permit it to retain the wave-like impressions of the saw. The coppery-red hue of the marrow extended up to the head of the bone; but it was not entirely uniform throughout, or, in other words, the marrow presented different shades of color in different parts. Opposite the surgical neck it had a dirty-red hue (brick-colored), and a somewhat

Marrow protruded.

[1] The account of the autopsy was written by the author.

[2] Vide Plate V.

softer consistence than elsewhere. There were no new osseous formations within the medullary canal or the interior of the bone. When examined with the microscope, the coppery-red, flesh-like marrow was found to be composed of granular marrow cells, some of which were very large in size, fat vesicles more abundant than they are usually seen in red marrow, connective tissue and spindle-shaped fibre-cells. The slightly yellowish tinge was derived from the fat vesicles. A specimen of the brick-colored marrow near the surgical neck was found to be very rich in large-sized, granular marrow cells, having large nuclei, many of which were as large as pus corpuscles. It also contained a few fat vesicles, spindle-shaped fibre-cells, and fibres of connective tissue. A considerable number of huge, granular, polynucleated fœtal marrow cells, was also found in the same specimen. Some of them had three, others four, five, or even six nuclei; and in one, nine distinct nuclei were counted. Spindle-shaped fibre-cells with elongated nuclei were also beautifully shown in the same specimen.

Fœtal marrow cells.

The next case is an example of purulent osteo-myelitis, and was observed in the author's military practice.

Case XV. *Secondary Amputation of Leg for Shell-wound of Foot; Purulent Osteo-myelitis; Thrombosis; Visceral Abscesses of the Lungs; Death from Pyæmic Pneumonia on the Eighteenth Day after the Operation.* — Private John G. Miramon, Co. L, 1st N. Y. Artillery, aged 23, admitted to the Stanton U. S. Army General Hospital, May 20, 1864, from the front, with a severe wound of the left foot; stated that he was wounded in the Wilderness, on the 18th, by the explosion of a shell. On examination it was found that a large portion of the heel had been torn off, and that the os calcis was much comminuted. On the 21st, the patient being fully under the influence of sulphuric ether, his leg was amputated, at its lower third, by the double-flap method. He lost but little blood, and did not suffer much shock from the operation. He reacted promptly after it.

He was then placed on the following plan of treatment, namely, tonics, nutrients, and alcoholic stimulants, to be administered, and simple dressings to be applied to the stump.

He died, however, June 8, of secondary or pyæmic pneumonia.

The *autopsy* showed suppurative inflammation of the marrow in the stump-bones, both of them being involved; thrombosis of the veins of the leg; secondary superficial abscesses of both lungs and lobular pneumonia.

Suppuration, osteo-myelitis, thrombus, and secondary abscesses.

Comments. — Osteo-myelitis of a destructive nature occurs not unfrequently in stump-bones after amputation; and the reason why this relation has hitherto not been generally recognized, is because the interior of these bones has not been examined with sufficient

frequency and care by our predecessors and contemporaries. Pirogoff's observations may be adduced as bearing important testimony on this point. He says, —

Pirogoff's observations.

"For the last twenty years I have made it a rule, in all cases where death has followed amputation, to split the stump-bone lengthwise with a saw. I have thus had very frequent opportunities to observe isolated abscesses, red hepatization, and dark-red discoloration in the medullary cavity of the diaphysis. Several very faithful representations of this condition, which I had made, are still preserved in the Museum of the Medico-Chirurgical Academy at St. Petersburg. I often found the periosteum unaltered in cases of destructive myelitis. Nor does the degree of structural changes in the medullary substance after traumatic amputations and contusions of bone always correspond to the intensity of the periosteal injury."[1]

If surgeons would more frequently copy the example of the illustrious Russian surgeon, and ascertain the internal condition of the bones in cases of death after amputation, and other injuries involving osseous structures, they would become better informed on this subject, and less likely to question its importance.

Foreign body in the bone.

In the *fifth* place, inflammation of the medullary tissue is very apt to occur if a *foreign body*, such as a bullet, or a fragment of bone, becomes *lodged in the medullary canal* of a long bone. Such a result was witnessed in Case No. III., that of Beaver.

Hennen says, —

Hennen's observations.

"I shall now advert to a species of the comminuted compound gunshot fracture, which, although at first of but little consequence in appearance, is of most serious importance in its results. This occurs where a musket-ball has perforated a cylindrical bone, without totally destroying its continuity, and, consequently, without producing any distortion of the limb, or other symptoms which characterize a fracture. The foundation of infinite mischief is, however, laid; for not only is the shaft of the bone injured, *but fragments are carried into, and lodged in the medullary canal;* and if the limb has been in an oblique position, or the ball has taken an oblique course, these fragments are often driven in to a great distance, and firmly impacted in its cavity, *there keeping up a constant and uncontrollable irritation, and destroying both the medulla and its membrane, together with the cancelli which naturally support it.* I have repeatedly seen this separated portion of bone lying in the medullary canal, at the distance of from four

[1] See chapter on "Wounds and Compound Fractures of the Bones of the Pelvis and Extremities," in Pirogoff's *Outlines of General Military Surgery.* Leipsic, 1864.

lines to an inch and a half from the circular hole formed by the passage of the ball, retaining its shape, its color, and its solidity, while all the surrounding osseous parts were diseased, and formed a spongy, discolored mass of bony granulations around it; the periosteum for some way, both above and below the wound, being entirely separated from the bone."[1]

CASE XVI. *Gunshot Wound penetrating the Femur; Detached Fragments of Bone, Pieces of Clothing, and a Portion of the Bullet lodged within the Femur; extracted them Six Months afterwards; Recovery;* contributed by Professor E. Andrews, of Chicago. — Lieutenant Stockton was shot, in August, 1863, at Vicksburg, in lower part of thigh, in front. The ball drove in a patch of bone on front of femur at broad part just above the joint, sinking the fragments into the cancellous tissue; joint not injured; the bullet split, and about two thirds of it were extracted soon after the injury; the probe at that time detected no other foreign body.

Splitting of the bullet.

In February, 1864, the fistulas were still open, the bone enlarged, and the soft parts inflamed and swelled. I then succeeded in touching dead bone with the probe; and, on cutting down, found the bone injured as above described. I took out several fragments of bone, two pieces of his pants, and a portion of the bullet which had been split off by the edge of the bone.

Bullet, cloth, and bone in femur.

The patient afterwards recovered rapidly.

Pirogoff, while speaking of the various forms in which osteo-myelitis presents itself, remarks that "not unfrequently it is a purely local trouble, showing itself, for instance, around a foreign body lodged in the bone, circumscribing itself from the healthy medullary substance by a distinct line of demarcation." The case last related probably belongs to this category.

In the *sixth* place, the occurrence of osteo-myelitis is promoted by the *scrofulous diathesis*. A very large proportion of the cases of this disease, especially in civil practice, is met with in strumous constitutions.

Influence of scrofulous diathesis.

The following case presents us with an example of scrofulous osteo-myelitis. Several additional cases of scrofulous inflammation of the medullary tissue may be found in other parts of this essay.

CASE XVII. *Acute Osteo-myelitis occurring without any Apparent Cause besides Struma; Recovery, with Extensive Exfoliation of the Tibia,*

[1] Vide *Principles of Military Surgery*, pp. 123, 124.

and Permanent Anchylosis of the Knee-joint; reported by Mr. Stanley.— A youth, aged sixteen, having a strumous constitution, complained of slight pain in the knee-joint, which had not arisen from local injury or any other apparent cause. At the same time, a little thickening and tenderness were discovered in the soft parts upon the inside of the head of the tibia. These symptoms continued several days, but little influenced by treatment, when the most acute inflammation suddenly arose within the joint, and in the soft parts around the head of the tibia. The accompanying pain was most severe; active local depletion did but little to mitigate it. There was also high inflammatory fever with delirium, which continued, without intermission, above a week, and was not calmed by the largest doses of opium. All these symptoms were relieved, however, by the bursting of a large abscess a little below the knee. Extensive denudation of the tibia ensued, and was followed by exfoliation of a large portion of its shaft with permanent anchylosis of the knee-joint.[1]

Acute osteo-myelitis from struma.

In the *seventh* place, inflammation of the medullary tissue of the long bones may be produced by *constitutional syphilis.* Clinical observation has shown that there is not only an inflammation of the periosteum and of the osseous tissue which has a venereal origin, but that there is also an inflammation of the marrow, having an extremely painful character, which results from the syphilitic dyscrasia. It is probable that, in many cases of constitutional syphilis, the severe nocturnal bone-pains which have commonly been referred to inflammation of the periosteum and the bone, are, in reality, produced by inflammation of the marrow. Percival Pott, who is admitted by all to have been a very acute observer, also believed that syphilitic disease of the cranial bones not unfrequently had its origin in the diploe, or, in other words, in the medullary tissue. On this subject he says, —

Syphilitic inflammation of the marrow.

"The separation of a portion of the cranium consisting of both tables, or of the whole thickness, happens not unfrequently in old or neglected venereal disorders. The disease, which, in these cases, *has its seat in the diploë*, often spoils the whole substance of the bone, and produces a separation or exfoliation of its whole thickness; the dura mater being always found, in such case, to be covered only by an incarnation generated from its surface."[2]

In the diploe of cranium.

The next two cases are instances of syphilitic osteo-myelitis occurring in the tibia.

CASE XVIII. *Non-traumatic Osteo-myelitis of Left Tibia induced*

[1] Vide Stanley on *Diseases of the Bones*, p. 54.

[2] Vide Pott's *Chirurgical Works*, vol. i. p. 125. London, 1779.

probably by Syphilis; Sudden Death from Erysipelas of the Head and Face; Autopsy of the Limb; reported by B. Phillips, Esq. — W. C., a shoemaker, aged 32, suffered from terrible pains in the left tibia, some months after having been affected with primary syphilis.

So excessive were the pains that it was found necessary to give him opium every hour, which, in considerable doses, was almost powerless. An incision was made along the spine of the tibia, which procured him a little relief. He was attacked by erysipelas, which affected the head and face, from the effect of which he died in thirty-nine hours.

The tibia, in which the pain had been seated, was examined; there was no disease of the periosteum, except a little tumefaction on either side of the incision which had been made, and a very little pus at another point. Upon making a longitudinal section of the bone, it was found that disease, to a considerable extent, existed in the canal, commencing about an inch from the tuberosity, and terminating at two inches from its inferior end.

Syphilitic osteo-myelitis, in tibia.

Along that portion, of about five inches, there was congestion and great thickening of the medulla, and, between it and the bone here and there, lymph, granular bodies, osseous nuclei, and small foci of pus; and wherever the pus was found, the bone looked earthy and of a dull yellowish-white color; the medulla had acquired a great increase of density. Had the man's life been spared for another week or ten days, the examination would, I doubt not, [says Mr. Phillips,] have been still more interesting.[1]

CASE XIX. *Syphilitic Osteo-myelitis (chronic) of the Tibia, accompanied with Intense Nocturnal Pains, which resisted all Treatment until the Bone was Trephined;* reported by Langston Parker. — E. C. entered the Queen's Hospital, under Mr. Parker's care, in August, 1851, with various syphilitic symptoms. Her chief complaint, however, was of severe nocturnal pains in the tibia of the right leg, which was somewhat enlarged, and tender to the touch; the pain in the bone was so severe as to prevent sleep altogether; she took the iodide of potassium, and the biniodide of mercury, with little or no benefit; blisters afforded, at first, a temporary alleviation from pain for a few days, but at length ceased to afford even a slight relief. The patient suffered so much that she repeatedly begged of me to amputate her leg. The case was one of secondary syphilitic inflammation, affecting the medullary tissue of the shaft of the tibia, which, in a minor degree, is, in my opinion, a very frequent cause of pains in the long bones. I determined to trephine the bone, to open the medullary canal, and let the blood flow from the divided vessels of the bone and medullary tissue. This was done while the patient was under the influence of chloroform, on September 21. I opened the med-

Syphilitic inflammation in interior of shaft of tibia.

Bone trephined.

[1] Vide *London Medical Gazette*, vol. xiii. pp. 191, 192.

ullary cavity with a long-crowned trephine. On removing the bone, the medullary membrane, turgid with black blood, which ran from it in a stream, protruded through the opening; the perforation was filled with a piece of soft lint dipped in oil. No medicine was given.

On the 24th, pain was no longer felt; the opening closing rapidly with new bone.

On November 7th, I removed a second piece of bone with the trephine, which was carious; and, in doing so, I penetrated the medullary canal a second time. Not the slightest constitutional disturbance followed either operation. The patient left the hospital well on October 10th.[1]

The same writer is inclined to refer the nocturnal pain of syphilitic rheumatism (so called) to a syphilitic inflammation of the medullary tissue. He says, —

"In the shafts of the long bones, it is exceedingly probable, if not certain, that these pains are due to syphilitic inflammation of the medullary membranes[2] of these bones. I have elsewhere shown this to be the case."[3]

Mr. Parker has also recommended the operation of trephining, in some painful affections of the bones, for the purpose of relieving diseased conditions of their interior, besides those which are marked by the formation of purulent matter. L. Parker on trephining bone.

He has expressed the belief that many of these painful affections of bone are due to an inflammation of the medullary tissue of the shaft or of the cancelli; and he is very sanguine that amputation may frequently be avoided by perforating the bone, and, if necessary, promoting the discharge by the introduction of a seton.

He also says, —

"I have now performed the operation I have just alluded to in six different cases, for painful affections of the bones, which have resisted all other modes of treatment, and in each case with success. No constitutional disturbance of any importance has followed any of these operations."[4]

In the *eighth* place, we recognize a *rheumatic form of osteo-myelitis*, that is, an inflamed condition of the medullary tissue, which appears to be produced by the same causes as engender articular rheumatism. Rheumatic osteo-myelitis.

[1] Vide Parker's *Modern Treatment of Syphilitic Diseases*, pp. 241, 242. Third edition, London, 1854.

[2] The reader will here please substitute the word tissue in place of membranes, since there is, strictly speaking, no such membrane.

[3] Vide *op. cit.* p. 240.

[4] Vide *American Journal Medical Sciences*, October, 1853, p. 441.

The following case, reported by M. Chassaignac, seems to belong to this category. The only causes to which the accession of the disease, in this instance, can be ascribed, are, firstly, a seizure of his arm in sport, and, secondly, the exposure of his body for a number of hours in a damp place. Now it is very difficult or impossible to conceive in what way the simple grasping of the soft parts of his arm could bring about a destructive inflammation of the medullary tissue sheltered within the bony canal of the humerus, without producing a destructive inflammation of the parts external to the bone; and we therefore deem it highly probable that the disease was occasioned by the dampness of the place in which he remained for three or four hours. Indeed, it does not appear at all probable that this young man would have got osteo-myelitis without such exposure to the operation of causes which, it is well known, are capable of producing articular rheumatism in certain habits of the body.

CASE XX. *Suppurative Osteo-myelitis of Left Upper Extremity; the Swelling characteristic of that Disease; Amputation at the Shoulder-joint; Recovery.* — Charles Aubain, a domestic, aged 16, temperament lymphatic, and health feeble, entered the Saint Antoine Hospital, September 21, 1849. About two months previously his left arm had been strongly grasped by a comrade in sport. Ever since that time he had experienced a slight pain in it. Five days previously, after having spent three or four hours in a damp place, he was seized with complete insomnia, fever, loss of appetite, intense thirst, and a feeling of some pain in his left arm. When he entered the hospital, the patient exhibited an increase in the size of his left arm, extending up to within less than two inches of the humeral extremity. The swelling was circumscribed above by a hard and clearly defined margin; the skin was reddish, and the sensibility acute, especially on pressure; the pain was lancinating, and there was obscure fluctuation. Chassaignac diagnosticated deep-seated suppuration; two incisions were made down to the bone, the one on the internal surface of the arm about an inch and a quarter above the elbow-joint, the other on its external surface at the same height. By these two incisions a great quantity of purulent liquid was discharged.

Chassaignac's case of rheumatic osteo-myelitis.

Suppuration.

September 23. — The next day after the incisions; the fever continues; his general condition is somewhat better; made a new incision at the external part of the elbow; suppuration profuse.

September 28. — The patient is much debilitated, and exhibits anæmia of a strongly marked character; pulse dicrotic;[1] a continued bellows, murmur in the carotids and a bellows-murmur accom-

Bellows-murmur.

[1] Derived from *dicrotus*, an epithet given to the pulse when it seems to beat twice as fast

panying the first sound of the heart; pallor of the mucous membrane; secretion of pus constantly profuse, very thin, and very fetid. In the course of the day he experienced a well marked chill, followed by sweating (aconite).

September 29. — Condition the same. The emaciation and the exhaustion are increasing (aconite 2 grammes).

September 30. — Counter-opening at the elbow.

October 1. — Invasion of the joint (elbow) by the pus; range of motion of the head of the radius more extensive than natural; crepitus under the fingers; pulse frequent, 100.

October 2. — Chassaignac practiced exarticulation of the arm by the method of Lisfranc. In spite of a great number of ligatures, the blood continued to stain a napkin; united the parts together by four pins; dressed by occlusion. Amputation.

Examination of the Amputated Member. — At the lower part of the anterior brachial region a deep-seated abscess of the size of a walnut was found; this abscess did not communicate with the joint. The periosteum was detached to the extent of almost two and one half inches. This detachment involved the external third of the member. At other points the periosteum was thickened and easily torn off. The external surface of the bone was red, injected, and exhibited the first stage of ostitis. On dividing the humerus lengthwise through its whole extent, it was noticed that the medullary membrane [tissue] was very easily detached. The medullary cavity presented all the stages of osteo-myelitis, from that of simple injection up to that of suppuration. The elbow-joint was also a purulent depot communicating with the pus which infiltrated the surrounding tissues; its ligaments were softened and partially destroyed; its cartilages were eroded and almost entirely destroyed. The radius, divided longitudinally, exhibited ostitis in the first stage. The ulna was completely intact. The vessels did not contain any traces of pus nor any sanguineous clot.

The patient got entirely well, and was seen a long time afterwards.[1]

Comments. — In support of the opinion that this case of osteo-myelitis had a rheumatic origin, it may be stated that the constitutional symptoms, in great measure, preceded the local ones; that after exposure to the dampness, the patient was seized with fever of a high grade, as was denoted by the intense thirst, the loss of appetite, and the entire inability to sleep. At the same time he did not experience much pain nor present any local swelling, heat, or other symptoms denoting the existence of a phlegmasia such

as usual. It is synonymous with the term *rebounding*, the artery rebounding after striking, so as to convey the sensation of a double pulsation. — Dunglison's *Medical Dictionary*.

1 Vide *Traité Pratique de la Suppuration*, etc., par E. Chassaignac, vol. i. p. 495. Paris, 1859.

as would account satisfactorily for the great amount of the constitutional disturbance. This patient, then, appears to have been suffering from an idiopathic fever contracted by remaining several hours in a damp place. Now let us ask ourselves what the nature of that idiopathic fever probably was. The subsequent history of the case enables us to say with confidence that it was not malarial, nor typhous, nor typhoid, nor catarrhal, in character. What, then, could it have been, if it was not a rheumatic fever? By this term is meant a febrile movement such as we not unfrequently find to present itself at or just before the advert of acute rheumatism in the great joints. It therefore seems highly probable to the writer, that such was the nature of the fever in this case, and that it proclaimed the advent of a rheumatic inflammation, not in the joints, but in the medullary tissue of the humerus.[1]

Limited swelling in soft parts.

Another point of great interest in the symptomatology of this case is the fact that the swelling of the soft parts extended up the arm to the same height as the inflammation of the medullary tissue, as was shown on examining the limb after amputation, and that it was bounded there by an abrupt, hard, and clearly defined border. In a practical point of view, this symptom possesses peculiar significance in this class of cases; for it informs us of the limits occupied by the disease, with considerable accuracy, and in this way gives us much assistance in making a diagnosis.

Color of the swelling.

Furthermore, this diffuse, flat-shaped, well-defined swelling of the arm, although it was very tender under pressure, was *not red*, but only *reddish*, in color. These points in the symptomatology of spontaneous osteo-myelitis will be considered again in another part of this essay.

Value of exarticulation.

Exarticulation at the shoulder was the remedy which saved this patient's life, and, on that account, it challenges the attention of the practical surgeon. It is worth while to remember that, notwithstanding the emaciation, the exhaustion, and the *pyæmoid* condition of this patient, he made a good recovery.

Mr. Stanley also relates a case of suppurative osteo-myelitis in-

[1] Dr. Klose describes the symptoms of the rheumatic form of the disease which is generally called osteo-myelitis. Among the most striking of the symptoms are intense pain in the affected part, and a severe rigor, followed by continued heat and great fever. The periosteum speedily becomes detached from the bone, and separated from it by an ichorous pus. Vide Barwell *On Diseases of the Joints*, p. 222.

volving the tibia which probably had, at least in part, a rheumatic origin. It occurred in a youth of 18, who had sprained his ankle and lain on the wet ground. The whole of the tibia, together with the knee and ankle joints, were invaded by the disease, and the patient was brought very low. Amputation of the thigh was performed as a remedy of last resort, and, with complete success, as the patient got entirely well.[1]

Mr. Stanley's case.

In the *ninth* place, osteo-myelitis of a severe character has, in more than one instance, been known to follow an *idiopathic fever*, or what seemed pretty certainly to be such. The next two cases are examples of it. One of them occurred in the practice of Hey, and the other in that of Gooch.

Idiopathic fever a cause.

Case XXI. *Suppurative Inflammation of the Medullary Tissue of the Tibia in its Middle Part following a Fever; Spontaneous Perforation of the Tibia and Outflow of the Pus; enlarged the Hole in the Bone, and took out all the Diseased Substance from its Inside with Instruments; Patient made a Good Recovery without Exfoliation.* — A young lady consulted Hey, towards the close of the year 1786, on account of a small tumor on the anterior and middle part of the tibia, and gave him the following account of it: In the preceding May, she had a fever, which continued about four weeks; at the expiration of which, a violent pain began to affect her leg. The pain continued without intermission six weeks, and then abated upon the appearance of a small swelling on the shin. She could then walk about with little or no uneasiness; but sneezing or coughing caused a painful sensation in the swelling.

Hey's case.

Upon cutting it open, Hey found the periosteum diseased and thickened; it was separated from the tibia, and included a small quantity of pus. The surface of the tibia was rough, as far as the matter had covered it; and in the centre of the rough part there was a hole equal in bore to a goose-quill, which led into the medullary canal, and through which the matter had escaped from that cavity.

Hey enlarged the hole in the bone enough to allow him to remove all the diseased tissue from its interior. The patient recovered with a good limb and without any exfoliation.

He makes the following remarks about it: "Upon a review of the case, I am inclined to think that an abscess was formed within the tibia, in consequence of the fever which she had in May, 1786. During the continuance of the fever, she had no particular pain in her leg; but upon the decline of the fever, the pain commenced, and continued violent for six weeks. It seems most prob-

Abscess within the tibia.

[1] Vide Stanley *On Diseases of the Bones*, pp. 52, 53, Am. ed., 1849.

able that during this time the matter was making its way through the anterior lamella of the tibia, and that the pain abated soon after the matter had perforated the bone; for it ceased immediately on the appearance of a tumor on the shin. It is surprising that such a perforation should have been made through so firm a part of the bone, without any extensive caries in the lamella, especially as the lamellated part of the tibia was remarkably firm and thick. The perforation appeared as if it had been made with a gimlet. The pain was so great during this operation of nature, that my patient assured me, and that immediately after the removal of the carious part of the bone, that she had suffered more pain during the whole six weeks above mentioned, unless when she was asleep, than I had caused during the operation necessary for removing the unsound bone." [1]

The first part of the account of this case is considerably abridged from that given by Hey.

CASE XXII. *Acute Osteo-myelitis of the Tibia occurring in the Course of a Fever; Marrow suppurated; Extensive Necrosis; Amputation; Recovery;* reported by Gooch. — J. A. of N. B., about 40 years of age, was seized in February, 1740, with a fever, attended with most violent symptoms; and, in about a fortnight, a swelling suddenly appeared upon the whole leg, accompanied with great inflammation and pain, and matter was soon discovered from the knee to the ankle, which upon opening was found very ill-conditioned and the bone carious its whole length.

Gooch's case.

The limb was amputated, and the reporter continues his account as follows: "Upon examining the limb after it was taken off, we found the *tibia full of purulent matter, instead of marrow*, which had corroded the bone quite through in an infinite number of places, and in two places it was totally divided.

Abscess within the bone.

No part of the bone was free from the caries, but the *callus* had evidently most resisted the acrimony of the matter.

The man was in a very bad condition to bear the operation, on account of the fever, a cough, etc.; but it succeeded, and he recovered a good state of health." [2]

The case is also illustrated with a drawing of the diseased tibia.

Osteo-myelitis without appreciable cause.

In the *tenth* place, inflammation of the medullary tissue of bone has not unfrequently been found to occur *without any appreciable cause.* The following case is in point.

CASE XXIII. *Suppurative Inflammation (chronic) of the Medullary Tissue in the Bones of the Tarsus and Metatarsus; no Cause apparent;*

[1] Vide Hey's *Surgical Observations*, p. 26 to 32, London, 1810.
[2] Vide Gooch's *Surgery*, vol. ii., pp. 349, 350, London, 1792.

no Operation admissible; Result fatal. — An old man of 70 was admitted into St. Bartholomew's Hospital for disease in his foot, which commenced twelve months previously, without apparent cause. A fistulous passage in the upper part of the foot extended to the tarsal bones, and, at the bottom of it, much rough and loose bone was felt. The disease spread gradually through the entire tarsus and metatarsus, accompanied by sloughing and suppuration in the surrounding soft parts. Amputation of the limb could not be proposed, on account of the feebleness and advanced age of the patient. He died two months after his admission. On examining the foot, Mr. Stanley found that the articular cartilages had disappeared from all the joints of the tarsus and metatarsus, and that the cancelli of the bones were filled with purulent fluid. Every tarsal and metatarsal bone was the seat of suppuration through its spongy tissue.[1]

Case reported by Stanley.

Again, clinical observation and reflection have convinced me that *the transportation of our wounded during the late war exerted an important influence in the production of osteo-myelitis*. My attention was first directed to this subject about the middle of June, 1863, when a considerable number of patients who had sustained gunshot fractures of the lower extremities were brought to the Stanton U. S. Army General Hospital from the Depot Field Hospital of the Army of the Potomac at Potomac Creek, where they had been under treatment since the battle of Chancellorsville, a period of about six weeks, and progressing favorably up to the time of their removal from that place. Now, all of these patients were rendered very much worse by the transportation. Those having fractured thighs suffered most.[2] Fresh inflammation was kindled in the soft parts surrounding the place of fracture, and more or less constitutional irritation was also produced. Several of these patients died of what I now know was osteo-myelitis; and there was good reason for believing that most of these fatal cases would have recovered if the exigencies of the military service had not rendered the evacuation of Potomac Creek a matter of necessity. I think that, beyond a doubt, the injury incidental to the transportation of these patients from Potomac Creek to Washington tended strongly to the development in them of destructive inflammation of the medullary tissue. That the want of success which attended their treatment at Stanton

Transportation as a cause.

Author's experience during the late war.

[1] Vide Stanley *On Diseases of the Bones*, pp. 54, 55, Am. ed., 1849.

[2] Vide *supra* in this connection, Case No. IV., that of Elisha Harrington. This patient had gunshot fracture of the thigh, and was transferred from Potomac Creek at the time indicated. The last paragraph in the comments on this case may also be advantageously consulted here.

Hospital was not due to any local miasm, was proved by the fact that the secondary amputations which were performed at that time, did remarkably well.

My attention was again called to the same subject in the summer of 1864. It was observed in some of the Army General Hospitals at Washington, and, I believe, in all of them, that osteo-myelitis and kindred disorders were met with much more frequently among the wounded brought directly from the Army of the Potomac, in the campaign of 1864, which extended from the Rapidan to the James River, than in the campaigns of 1862 and 1863 upon the Rapidan and Rappahannock. At first I thought that the difference might possibly be attributed to a general scorbutic taint of these troops; but I found, on inquiry of the proper parties, that the Army of the Potomac was less afflicted with scurvy, and had a better state of general health, in the spring of 1864 than in 1863, or even in 1862. I next suspected that this increased tendency to the occurrence of osteo-myelitis might be occasioned by a deficiency in the supply of food after the campaign of 1864 opened, but satisfied myself, on investigation, that the troops had never been supplied with rations better in any of the preceding campaigns. I then inquired whether this increased liability to destructive inflammation of the medullary tissue might not be due to the more arduous nature of the service in which the troops were engaged in 1864, but failed to find therein a satisfactory explanation; for the labors of the Army of the Potomac were not, upon the whole, more severe and exhausting to the men in that year than in 1863. Failing thus to find a satisfactory explanation of the remarkable tendency already mentioned, in the constitutional condition of the soldiers, I was next led to inquire whether it might not with propriety be referred to the circumstances by which the wounded were surrounded directly after the infliction of their injuries. And then the subject of the comparatively long transportation in ambulances and army wagons over rough roads, to which great numbers of those wounded in the battles between the Wilderness and Cold Harbor inclusive, in 1864, were subjected, stood out in bold relief; and I am thoroughly satisfied that this affords the true explanation of the prevalence of osteo-myelitis among the wounded brought from those battles. It is not difficult to conceive how the jolting which is inseparable to the transportation of the wounded in any vehicle on wheels over rough country roads, may assist strongly in producing inflammation of the medullary tissue, especially in those who have

Campaign of 1862, 1863, and 1864 contrasted.

Battles of the Wilderness, Cold Harbor, etc.

suffered gunshot fracture of the long bones, but most of all in those who have suffered a gunshot fracture of the femur. In the first place, the jolting movements of the vehicle may cause the fragments of broken bone, if they are in apposition, to rub against each other in such a way as to excite inflammatory irritation in the periosteum, the bone itself, and the marrow, or even thrust spiculæ of bone into the medullary canal. In the second place, the jolting of the vehicle may cause the soft parts to be pierced, and torn, and bruised against the broken bone, whereby an inflammation is lighted up in the soft parts, which in turn may spread by contiguity to the periosteum, the osseous, and the medullary tissues. Whether this be the true explanation of the way in which the length and roughness of the transportation of the wounded tend to produce osteo-myelitis or not, I am strongly impressed with the belief that they do exert such a tendency; and I am strengthened in that opinion by the statement of Dr. Moses that osteo-myelitis was more frequently seen in the Confederate Hospital at Charlottesville among the wounded in the Maryland and Pennsylvania campaigns, than among those wounded at nearer and more accessible places, and also by the statement of Surgeon Henry Janes, U. S. Vols., that but comparatively few cases of this disease occurred among the wounded at Gettysburg who were treated near the field of conflict.

Statements of Drs. Moses and Janes.

The following case has been contributed by Dr. David Prince since the foregoing was written, for the purpose of illustrating still further the influence of transportation in producing osteo-myelitis.

Simeon Dugger, Co. C, 10th Illinois Vol. Infantry, a new recruit in a veteran regiment, was wounded in the shoulder on or about the 28th of June, 1864, in the battle of Kenesaw Mountain, Georgia.

Dr. Prince's case.

The bullet comminuted the head of the scapula, on account of which the head of the humerus was excised soon after the injury.

This man did well, and obtained from a military hospital in Nashville a furlough to go to his home near Jacksonville, Ill., *without money and without any person to attend to him.*

He arrived in Jacksonville greatly exhausted, and with diarrhœa, July 28, one month from the time of the injury. The wound had united, except two small openings, which were discharging sanious matter.

The arm had been tightly bandaged by some medical man a few hours before his arrival, and some swelling existed about the elbow,

which gradually increased until it was opened, August 5. Subsequent probing revealed denudation of the humerus to a large extent.

The patient's diarrhœa was speedily checked by some quinia, stimulating drink, good food, and rest, and yet he steadily lost ground.

On his first arrival a sustained splint had been applied, but it had to be discontinued on account of the swelling about the elbow.

The day the abscess was opened, he was carefully moved about two miles for better attention.

August 12. — He has steadily lost ground, and he has bled from the opening near the elbow four times in four days, and a new opening has sloughed near the internal condyle. The diarrhœa is entirely controlled, and the dryness of the tongue is only moderate, and yet the appetite is nil.

Exarticulation of arm.

Amputation at the shoulder-joint, under ether $\frac{3}{4}$ ʒ, chloroform $\frac{1}{4}$ by bulk; pulse before the amputation, one hundred and four; after amputation, one hundred and twenty.

The brachial artery was found to be involved in the destruction going on near the elbow, from the branches of which the hemorrhage had come.

The humerus was found denuded of periosteum, on its anterior surface, over one third of the length of the shaft, and extending into the elbow-joint, separating the articular cartilage from the trochlear surface.

No communication was found between this suppurating cavity and the original wound, and the periosteum over all the upper portion of the bone was in a healthy condition.

The angular circumference of the upper end of the fragment had been rounded off by exfoliation. The glenoid projection of the scapula was found to have been extensively comminuted.

The patient died two days later from progressive exhaustion, though his comfort was much augmented by the amputation.

It is probable that this man would have recovered without difficulty, if he had remained quietly at Nashville, and had not attempted to make the journey to Jacksonville in Illinois.

Symptoms not uniform.

Symptoms of Osteo-myelitis. — The *symptoms* are not alike in all cases of this disease. They present considerable variety in different instances, in accordance with the acuteness of the attack, the location and extent of the medullary tissue involved, the stage of the disorder, the condition of the neighboring soft parts in respect to structural lesions inflicted by accidents or by surgical operations, and the condition of the diseased bone itself in the same respects. If the inflammation of the marrow be complicated with a traumatic inflammation of the bone, or of the periosteum, or of the soft structures which overlie

them, the symptoms will vary accordingly. The phenomena attending osteo-myelitis induced by gunshot contusion of a long bone in its continuity, such as the femur, often differ considerably from those attending osteo-myelitis of a stump-bone after amputation; and the symptoms of that disease, where it is produced by a traumatic solution in the continuity, are, in general, not exactly the same as when it occurs spontaneously, and all the neighboring parts are uninjured. Osteo-myelitis, non-traumatic in its origin, that is, inflammation of the medullary tissue of bone, occurring either spontaneously, or produced by causes that are constitutional in their operation, such as the strumous, the syphilitic, and the rheumatic diatheses, affords, upon the whole, the best opportunity to study the symptomatology, because the disease, under these circumstances, is not complicated by an inflammatory mischief in the surrounding parts which may obscure or even conceal the inflammation of the marrow. We shall therefore proceed to describe first the symptoms of osteo-myelitis occurring in an uninjured bone, and afterwards those produced by the traumatic forms of the disease.

Symptoms when there is no lesion of bone.

The development of acute osteo-myelitis in a limb which has not been wounded, nor been the subject of a surgical operation, is attended by the phenomena which usually pertain to the severe phlegmasiæ, such as pain, heat, redness, swelling, and symptomatic fever. Of these symptoms, the *local pain* is the first to make its appearance. It always precedes the other phenomena in non-traumatic inflammation of the medullary tissue, provided it is acute in character.[1] Case No. XX. does not afford an exception to the accuracy of this statement; for the febrile movement of a high grade, which appeared at the commencement of it, was rheumatic in origin, and symptomatic at that time, not of inflammation of the medullary tissue of the humerus, but of a pathological condition of the system at large, which might soon result in rheumatic inflammation of the joints on the one hand, or in rheumatic inflammation of the marrow on the other, neither of which, however, had yet taken place. The febrile movement which was symptomatic of the local inflammation appeared later in that case, and when the other symptoms of phlegmasia, such as heat, swelling, and redness, had appeared. But the local pain is not only the earliest symptom of spontaneous osteo-myelitis; it is also very

Local pain.

Severe and constant.

[1] Vide *Traité Pratique de la Suppuration*, etc., par E. Chassaignac, t. i. pp. 470, 472. Paris, 1859.

severe and distressing in character, and becoming more intense as the disease becomes more fully developed. It is, likewise, constant both by night and by day, and continues until the escape of the pus imprisoned within the unyielding tissue of the bone has been effected by spontaneous perforation of that tissue,[1] or by artificial perforation made with a trephine, or until the diseased member has been removed by amputation, or until death itself has been produced.[2]

This intense, aching pain is also located in the bone at the place where the marrow is inflamed; and, in general, the precise seat of the pain in its greatest intensity, is where the disease of the marrow is most fully developed. Sometimes, however, the pain is diffused at the commencement, through the whole of the limb, in one of the bones of which the disease is located; but afterwards it becomes confined to the spot or place where the medullary tissue is inflamed.

The pain is peculiar, as if the bone was being broken.

According to Chassaignac, this *pain* is peculiar in one respect; and the patient suffering from it has the sensation or impression that the diseased bone is undergoing fracture. He states that, almost without exception, he has found this singular sensation to be experienced by the patients suffering from osteo-myelitis and from acute periosteal abscess, who have come under his observation. He says, the diseased limb of such a patient cannot be raised up in order to place it upon a pillow or a folded sheet, but that he immediately cries out, "You are breaking my leg!" if the lesion happens to be situated in the lower extremity. He also remarks that this sensation of fracture without fracture, which is present in some of the most severe forms of acute disease of the osseous system, is worthy of special notice.[3]

Again, the *pain* produced by osteo-myelitis differs very much from that which is occasioned by diffuse cellulitis, and by acute periosteal abscess; for, in patients afflicted with either of the two diseases last named, the pain is mitigated considerably by making incisions into the soft parts in such a way as to relieve the tension and to thoroughly evacuate the pus, while, in patients afflicted with suppurative osteo-myelitis, the pain

Not relieved by incisions in the soft parts.

[1] Vide Case XXI.

[2] Ollier has found, by experiment on animals, that the marrow, unlike the periosteum, is exceedingly sensitive to pain when irritated, and that its sensibility increases in proportion to the nearness of the source of irritation to the nutritious foramen of its containing bone. See *American Journal Medical Sciences*, January, 1868, p. 148.

[3] Vide *Traité Pratique de la Suppuration*, p. 471, t. i.

is not much relieved unless an aperture is also made in the bone, through which the imprisoned purulent matter may flow away. It therefore obtains that when a limb supposed to be affected with diffuse cellulitis, or with acute periosteal abscess, has had evacuative incisions properly made into it without ameliorating the local pain, there is good reason to inquire whether, independently of these two lesions, a suppurative inflammation, still more deeply seated, is not going on within the osseous tissue itself.

The symptoms which make their appearance next after the pain, in acute osteo-myelitis, non-traumatic in its relations, are *unnatural warmth* and *swelling* of the soft parts in the vicinage of the inflamed medullary tissue. The undue heat, speaking pathogenetically, is produced in the same way as it is in the other varieties of local inflammation. It is not characterized by any peculiar phenomena, and therefore does not require any particular notice in this place.

Unnatural warmth.

The *swelling*, however, which is produced by this form of osteo-myelitis, presents several features which are worthy of special attention. As already stated, it makes its appearance subsequent to the local pain. It begins as a puffiness, which is firm or hard in feel, and which is apt to pit under pressure, or prove to be œdematous in character. But when the disease is situated in the extremities, the tumefaction soon presents a considerable resemblance to that which is occasioned by diffuse cellulitis. In both disorders the swelling is flat-shaped, and extends over a considerable space. There is, however, this difference between them. In diffuse cellulitis the tumefaction generally sinks down and disappears in the neighboring parts; but in spontaneous osteo-myelitis it is bounded by an abrupt margin or brim, which corresponds very closely with the extent to which the medullary tissue is suppurating,[1] and as this disease travels up the medullary tube of a long bone towards the trunk, the swelling, with its sharply defined and depressed margin, likewise extends upwards with about the same degree of rapidity.[2] If this feature, which pertains to the tumefaction occasioned by acute spontaneous osteo-myelitis, is well marked, it is of very great importance in a diagnostic point of view. It enables us to affirm not only that osteo-myelitis is present, but to point out with

Swelling puffy, etc.

Terminates abruptly.

[1] Vide Case XX.

[2] Chassaignac, while speaking of the tumefaction which characterizes acute osteo-myelitis of the extremities, says there is formed, at the precise limit of the osseous suppuration, an abrupt rim, at which the hard and painful puffiness suddenly ceases. *Traité Pratique de la Suppuration*, p. 472 t. i.

considerable accuracy the limits of the disease. The "puffy tumor" of the scalp, which was first described by Pott, is an example of the kind of swelling which accompanies this disease when it involves the cranial bones. Surgeons have, for a long time, been cognizant of the import and value of this peculiar kind of tumefaction of the scalp in cases where the cranium has sustained an injury in the nature of a bruise or a linear fracture. The puffy swelling due to osteo-myelitis when it occurs in the extremities, is also an important symptom, provided it is clearly marked, and its boundaries are distinctly defined.

Puffy tumor of scalp.

With regard to the discoloration of the skin (redness) which accompanies acute inflammation of the medullary tissue, there is not much to be said, since it appears to be a matter of minor importance. The hue is generally reddish, and not deeply so, but it varies considerably in different cases. Sometimes, however, the redness of the affected part is intense, and accompanied by a lively warmth. Occasionally the parts are unnaturally pale.

Color of skin.

Another local symptom of considerable importance which may be occasioned by acute, non-traumatic osteo-myelitis, is the admixture of free oil with the pus discharged by incision from beneath the deep fascia in the vicinity of the diseased bone. Chassaignac states that in all of his cases of osteo-myelitis, without exception, he found the sub-aponeurotic pus extensively besprinkled with oil globules.[1] The author also has noticed free oil mixed with the pus discharged from the soft parts in the neighborhood of the seat of disease in at least one case of suppurative osteo-myelitis; and it is probable that he would now be able to distinctly recollect several other cases of that disease accompanied by an oily condition of the pus, if his attention had been sufficiently directed to this point at the time of their occurrence. Chassaignac further states that he has met with a similar admixture of oil globules with the pus in cases of acute periosteal abscess, but that he has not met with it in cases of diffuse cellulitis, even when the parts beneath the deep fascia are involved in the disease. The oily condition of the pus, therefore, indicates that either suppurative osteo-myelitis or acute periosteal abscess is present.

Free oil with the pus.

Also in acute periosteal abscess.

The acute variety of non-traumatic inflammation of the medullary tissue is always accompanied, as soon as the disease is fully developed, by considerable constitutional disturbance of a febrile

[1] Vide *Traité Pratique de la Suppuration*, t. i. p. 473.

character, or, in other words, by a fever which is symptomatic of the local mischief. This fever always shows a strong tendency to take an *irritative* type, and is accompanied by marked tokens of general debility. Furthermore, osteo-myelitis in an acute form almost always produces much disturbance of the nervous system, and sometimes even delirium.[1]

Irritative fever and delirium.

We will next proceed to describe the phenomena produced by inflammation of the medullary tissue in a long bone, the continuity of which has been destroyed either by casualty or by surgical operation, and the neighboring soft parts wounded, as, for example, by gunshot fracture, or by resection, or by amputation. When osteo-myelitis in an acute form invades the stump of an amputated limb, it usually becomes the seat of a severe, aching pain, which is deep-seated, and appears to the patient to be located in the diseased bone itself. The stump also becomes swelled, and both redder and hotter than natural. The tumefaction often has a puffy appearance, being œdematous, and pitting under pressure made with the fingers. The flow of pus from it, if union have not yet taken place, becomes diminished in quantity and thin, or serous in quality. Sometimes the purulent secretion becomes watery, and almost entirely ceases. Occasionally it is stained with hematoidin, and looks not unlike bloody serum. There is often a tendency on the part of the bone to protrude; and, if the sawn end of it be examined, the stump having been reopened if necessary to permit it, the marrow is found to be inflamed, and to protrude considerably from the medullary canal.[2] If this examination be made at an early period, the extruded marrow is found to be either red or reddish-brown in color, and toughened, sclerosed, or carnified in consistence. If, however, this examination be made at a late period, the inflamed or hepatized marrow is not unfrequently seen to be dotted with numerous foci of suppuration, and drops of pus may be observed exuding from it. At the same time the patient exhibits a great deal of constitutional disturbance. He is restless, agitated, nervous, and has fever of an irritative type. In bad cases he is also delirious, and much reduced in strength.

Symptoms when there is lesion of bone.

After amputation.

Puffy swelling of stump.

Marrow protrudes.

[1] Vide Case No. XVII.

[2] Pirogoff says, "A very frequent phenomenon in chronic osteo-myelitis after amputation is a fungous growth (exuberant) shooting out from the medullary canal, which now and then attains considerable size, and protrudes from the exposed end of the bone. When this growth has been very sensitive, I have found after death disseminated abscesses and dense (hepatized) red spots in the medullary substance." We should here remark that the marrow generally protrudes also, in cases of *acute* osteo-myelitis following amputation, from the end of the stump-bone.

The following case affords a good example of acute osteo-myelitis following amputation of the thigh, as it was seen in our military hospitals during the war, the symptoms having been carefully noted. It occurred in the author's practice.

CASE XXIV. *Suppurative Osteo-myelitis (acute) following Primary Amputation of Right Thigh for Gunshot Injury; Death Thirty Days after the Operation from Pyæmia; Autopsy; Secondary Abscess of the Lungs; Thrombosis of the Femoral Vein, with Puriform Softening of Clot.* — Private R. W. Lurchin, Co. F, 6th Maine Vols., aged 28, and of sound constitution, was wounded by fire-arms, in battle, near Fredericksburg, Va., May 3, 1863, and had his right thigh amputated primarily, by the circular method, at the junction of its middle and inferior thirds, for that cause.

Case in "Stanton" U. S. A. Hospital.

May 8. — He was brought to the Stanton U. S. Army General Hospital from the front; general condition good; directed the water-dressing to be applied to the stump.

May 11. — He is restless, and complains of having pain in the stump; pulse 104 and full; prescribed pulv. Doveri grs. v. et camphor. gr. i. ter in die.

May 15. — Stump suppurating freely; pulse 90; tongue coated; appetite poor; bowels confined; prescribed ol. ricini f. ʒ i., and allowed him to have milk-punch.

May 21. — His appetite continues poor; ordered him to take quiniæ sulph. grs. ii. in solution, three times a day, and to continue the milk-punch.

May 24. — He is restless, and again complains of pain in the stump; tongue coated and bowels confined; prescribed hydrarg. cum cretâ et pulv. rhei ää. grs. x. to be taken at once; to have milk and eggs for diet.

May 25. — The pain in the stump continues, and is referred to the bone by the patient; the stump is also swelled, and the discharge from it diminished in quantity; skin tinged slightly yellow; the presence of osteo-myelitis is affirmed; prescribed elixir. vitriol. gtts. x., to be taken with the quinine.

May 28. — His general condition is better; tongue and skin moist; but the bone-pain continues in his stump.

May 29. — He has passed a very restless night. The bone-pain in the stump has increased, and is now very severe. He has mild delirium, dyspnœa, and cough. Prescribed potass. iodid. ℈ i. dissolved in aqua camphoræ f. ʒ iv., and directed a tablespoonful to be taken every six hours, together with porter and any nutriment he may desire.

May 30. — Delirium increased; pulse rapid and feeble; the granulations have sloughed off from the end of the bone in the stump, and pus is now seen oozing from the marrow there.

May 31. — He is still worse; has profuse perspirations; pulse 130, quick and feeble; tongue brown and dry.

June 2. — He died at six o'clock A. M., of pyæmia.

The *autopsy* showed that the medullary tissue in the canal of the stump-bone was inflamed; that it had a dark-red color, an increased consistence (sclerosis), and contained a large number of small isolated or distinct abscesses, which varied in size from a pin-head to a pea; that suppuration was also going on among the muscular structures of the stump; that the orifice at the end of the femoral vein was not closed; that the vein itself was filled with a dirty-looking, gray-colored, semi-fluid substance, which resembled pus, for a considerable distance above the first valve from its end (puriform softening of the thrombus);[1] that there were about a dozen secondary abscesses in the superficies of the lungs (both); that these pulmonary abscesses varied in size from a pea to an almond; that the kidneys appeared to be fatty; and, finally, that the liver and spleen were normal. The femoral vein was empty, but considerably shrunken in calibre from its end up to the first valve, and above that point it was filled with puriform matter.

Softening of thrombus, and secondary abscesses.

Comments. — The clinical history of this case presents a strong resemblance to that of Case No. I. Both patients had sustained primary amputation of the thigh for gunshot injuries. In both of them the first symptom produced by the inflammation of the medullary tissue was pain, intense, seated deeply in the stump, apparently in the bone. In both of them the stump became swelled, hot, and tender; the discharge of purulent matter got deteriorated in quality, and diminished in quantity; the inflamed marrow was hepatized, and protruded from the medullary canal at the sawn end of the bone, and towards the close of life drops of pus were seen oozing from it. In both of them the symptomatic fever was well marked and irritative in character. There was thirst, a furred tongue, loss of appetite, a frequent pulse, a hot skin, restlessness, anxiety, much disturbance of the nervous system, and considerable debility. In both of them pyæmia supervened, and speedily proved fatal; and on making the autopsy, a number of isolated, small-sized abscesses, or foci of suppuration, were found scattered through the inflamed medullary tissue.

In the case just related, the first symptom of pyæmia appeared eight days before death. It was a jaundiced hue of the skin. Five days later dyspnœa and cough appeared. They were symptoms of pyæmic pneumonia. From this time he sank rapidly, and in three days died. The profuse sweats and the

Symptoms of pyæmia.

[1] Vide Virchow's *Lectures on Cellular Pathology*, pp. 233, 234. Am. ed.

dry-brown condition of the tongue were produced by the pyæmia. It is important in a practical point of view to separate the symptoms of osteo-myelitis from those of pyæmia.

The next case occurred in civil life. In it the discharge of pus was not diminished in quantity, although the quality was very much altered, and the odor very offensive.

CASE XXV. *Acute Osteo-myelitis (suppurative) following Amputation of Thigh, and accompanied by Extensive Separation of the Periosteum; Necrosis; Death on the Nineteenth Day; Autopsy; Secondary Abscesses in Lungs;* reported by B. Phillips, Esq. — A woman had her leg removed above the knee. For five or six days nothing remarkable occurred: on the application of the second dressing, it was noticed that there was a large quantity of pus; on the eleventh day there was much tumefaction, and she would scarcely allow the stump to be touched, so very painful was it; and upon the application of slight pressure, a large quantity of pus gushed out from a small aperture. On the fifteenth day the prostration was great, and it was ordered that she should take porter with small doses of opium and quinine; they produced no good effect. Diarrhœa, with stools every hour, succeeded on the sixteenth day, and on the nineteenth she died, the thigh being œdematous, presenting a yellowish tint, pitting much under pressure, the pus from the eleventh day being so fetid that the room was almost insupportable. Most of the viscera were in an unhealthy state; there were purulent collections in the lungs. The medullary tissue was detached from the bone to the extent of nearly three inches; the periosteum to a nearly similar extent; the medulla was broken down and infiltrated with pus, and the bone evidently dead. Above the point named, the medullary tissue was red, and more than usually firm; still higher, both were nearly in their natural state, though the cancelli were filled with an albuminous fluid.

Tenderness and tumefaction.

Pitting on pressure.

Fetid pus.

There were here three well-marked local symptoms: 1st, excessive tenderness and tumefaction of the amputated surface; 2d, profuse and fetid purulent secretion, unconnected with the amputated surface; and, 3d, a pitting upon pressure of the lower part of the thigh. These symptoms [says Phillips] have always been present in the cases I have seen at this stage of the disease.[1]

Comments. — The highly *fetid character of the pus* in this case, after the eleventh day, rendered the probability at the time strong that it was produced either from the bone itself or from the structures in immediate relation with the osseous tissue, such as the periosteum and the marrow.

[1] Vide *London Medical Gazette*, vol. xiii. p. 192.

The *profuseness* of the purulent secretion was also a symptom worthy of some attention in this instance. The discharge of pus appears to have been decidedly more copious than it would have been if it proceeded from the wound of operation alone. From this fact it could have been justly inferred at the time that there was a suppurating surface of considerable extent within the stump, in addition to that afforded by the wound of operation. The fetid character of the purulent discharge would have suggested that it came from the vicinity of the bone, and therefore from either the inflamed marrow or the periosteum, or both of them. The examination of the stump after death showed that the marrow was in a state of suppurative inflammation, and entirely separated from the surrounding bone to the extent of nearly three inches, and that the periosteum was detached to nearly the same distance from the end of the stump-bone. In this way a large suppurating surface was produced in addition to that afforded directly by the section of the parts made in performing the amputation, and by it the purulent matter discharged from the stump was, in great part, furnished. A suppuration more abundant in quantity than can be satisfactorily accounted for by the size of the wound of operation, or the extent of the raw surface from which it appears to be discharged, may, therefore, become a symptom of considerable practical importance. Mr. Hey, the celebrated English surgeon, turned it to good account in connection with a suppurating sinus of the leg; and, inferring from it that the interior of the tibia was diseased, he proceeded to perform a surgical operation on said bone, and obtained a very gratifying result.

Suppuration of marrow.

Suppuration profuse.

Again, in this case the bone was extensively necrosed, although no line of separation had been formed at the period when death occurred. The vitality of the osseous tissue appears to have been destroyed by cutting off its supply of blood, through the detachment, or the separation from it, of the marrow and the periosteum. Now this detachment of these vascular structures was directly occasioned by the inflammatory process; moreover, such detachment from the bone is a not uncommon result of the inflammation of those tissues. It is for this reason that inflammation of the periosteum and medullary tissue, especially in stump-bones, not unfrequently terminates in extensive destruction of the osseous tissue.[1] The portion of the bone which is deprived of an adequate

[1] Perhaps, however, traumatic necrosis, especially when it occurs in the flat bones and in the continuity of the long bones, is produced more frequently by secondary inflammation

supply of blood, dies in precisely the same way that the soft parts do when affected with dry gangrene. Such cases of necrosis may, therefore, without any violation of the rules of propriety, be called examples of dry gangrene of bone.

Dry gangrene of bone.

Furthermore, certain points in the pathological anatomy of osteo-myelitis were very distinctly seen in this case. The portion of the marrow which corresponded with the necrosed bone, was broken down and infiltrated with pus, or, in other words, it was the seat of suppurative inflammation. Above the part named, the medullary tissue was red in color and more than usually firm in consistence (carnified); and still higher up it presented a natural appearance. A passing allusion only is now made to this branch of the subject, as it will be fully discussed in another portion of this essay.

The next case, which also occurred in civil practice, is offered in further illustration of the symptomatology of osteo-myelitis.

Case XXVI. *Acute Osteo-myelitis (suppurative) following Amputation of the Thigh for Disease of the Knee-joint; Death on the Twenty-second Day from Pyæmia; Autopsy; Secondary Abscesses in Lungs; Saphena Vein contained a Puriform Liquid; Extensive Necrosis;* reported by B. Phillips, Esq. — A scrofulous lad, of seventeen, had suffered from a disease of the knee-joint, accompanied by ulceration of the cartilages, and succeeded by anchylosis; the leg had been permitted to anchylose at nearly right angles with the thigh; the limb was found inconvenient, and he determined to have it removed.

Amputation was performed without the occurrence of any drawback. On the removal of the first dressings, union had taken place, except at the point where the ligatures were situated. On the eleventh day there was a very manifest tumefaction of the stump, and great sensibility was displayed when it was dressed; the next day there was a general yellowness over the body; and when the dressings were being renewed, a little pressure caused the escape of a large quantity of fetid pus, which had also a yellowish tinge.

Amputation of thigh.

Yellow skin and fetid pus.

To these symptoms succeeded hectic fever, delirium, diarrhœa, and, on the twenty-second day, death.

On examination it was found that a portion of the medullary tissue was hanging from the canal in a sphacelated state; higher up in the canal were large quantities of pus; the bone was necrosed; the perios-

of the osseous tissue itself (ostitis), having an acute character, than it is by the mechanical detachment of the marrow and periosteum from the bone. See chapters on Ostitis and Necrosis belonging to this section, where this subject is discussed at considerable length.

teum was separated from the bone by purulent matter; the whole of the lower part of the thigh was infiltrated; the saphena vein was inflamed, and was loaded with pus[1] up to within half an inch of its junction with the femoral; the lungs were also infiltrated with the same substance; and to this I attribute [Mr. Phillips adds] the very fetid character of the breath in this case.[2]

Pus in saphena.

Comments. — In the acute forms of osteo-myelitis following amputation, the purulent matter discharged from the stump is almost always of poor quality, being either watery, flaky, sanguinolent, or fetid. The quantity of it is also affected by that disease, being, for the most part, considerably diminished thereby. Sometimes, however, the flow of pus from the stump is decidedly increased from the suppuration of the inflamed marrow and periosteum, as it appears to have been in the two cases last related. Besides these alterations in the character of the purulent matter secreted in the stumps of amputated limbs which are the seat of acute osteo-myelitis, still another one is present if the morbid process prove destructive to the bone. Under such circumstances the purulent discharge always contains more or less *debris* of the osseous tissue which is being demolished, in the shape of small granules of calcareous matter, resembling fine sand and minute fragments of the bone itself, which, when examined with the microscope, are found to contain lacunæ, canaliculi, and Haversian canals. We can readily turn this pathological fact to a practical account. If, in any case of suppuration, we are in doubt as to whether the osseous tissue is involved in that process, a microchemical examination of the purulent discharge will effectually settle the question.

Debris of osseous tissue.

In the *chronic* form of osteo-myelitis affecting stumps, the flow of pus, or the suppuration, is generally profuse. That variety of the disease generally occasions necrosis of the osseous tissue to a greater or less extent, and the dead bone in turn irritates the parts surrounding it, and thus occasions a copious secretion of purulent matter or a succession of abscesses. In such cases the pus may also be charged with the debris of the osseous tissue that is being destroyed in order to permit the separation of the dead from the living bone. Its quality, too, is generally altered

Chronic osteo-myelitis.

[1] In this case there had doubtless been thrombosis of the saphena vein, and what Mr. Phillips took to be pus was probably a puriform substance produced by purely chemical agencies during the softening of the thrombus with which the vein was obstructed. Vide Virchow's *Cellular Pathology*, p. 234. Am. ed.

[2] Vide *London Medical Gazette*, vol. xiii. pp. 192, 193.

from that of the laudable standard. In very chronic cases the author has occasionally seen it so thin and destitute of pus corpuscles that it looked not unlike a limpid, pale, straw-colored serum. In other cases of the disease in a chronic form, he has found it thin, dark-yellow in color, and very offensive in odor.[1] Sometimes, however, the purulent discharge is very healthy.

The symptoms of osteo-myelitis attending a compound fracture of a long bone, for example, a gunshot fracture of the femur, are, for the most part, the same as those produced by this disease when it follows amputation performed in the continuity of the same bone. In both cases there is generally deep-seated pain (bone-pain), unnatural warmth and swelling, with more or less redness of the soft parts in relation with the bone or bones which constitute the seat of the disease. The discharge of purulent matter is disturbed in the same way in both of them. In several instances of gunshot fracture, the comparative dryness of the wound, or the diminished quantity and thin, serous quality of the pus, have been among the earliest symptoms of osteo-myelitis that attracted the author's attention. The chief points of difference between them, in respect to symptomatology, may be referred to the fact that, in the stump of an amputated limb, the inflamed marrow can be seen at the end of the bone, and its precise condition noted while in cases of gunshot fracture the medullary tissue cannot be submitted to ocular examination, and its pathological condition can only be inferred.

Change in the wound.

Although severe *pain* is a constant symptom of those forms of osteo-myelitis which are not traumatic in their origin, and where the integrity of the bone is therefore preserved, it is not a constant symptom of the forms of the disease which are produced by amputation, resection, and compound fracture. The degree of the pain in traumatic osteo-myelitis is very much less in some cases than in others, and occasionally there is very little of it. We will therefore proceed in the next place to inquire into the conditions or circumstances which may modify the pain of osteo-myelitis by either increasing or diminishing its severity. We find, *firstly*, that the intensity of the pain produced by inflammation of the medullary tissue is, other things being equal, very much increased, if the neighboring osseous tissue is also inflamed; *secondly*, that the sensibility to the pain occasioned by inflammation

Pain as a symptom.

[1] Vide Case V.

of the medullary tissue, is decidedly diminished by the *hebetude of pyæmia, and of typhoid disease in general;* and, *thirdly*, that the osteo-myelitic pain is very much less, if the integrity of the compact tissue of the diseased bone be destroyed by perforation, division, or in any other manner that permits the protrusion of the swollen marrow, and the ready escape of the purulent matter from the medullary canal as soon as it is formed. The author has not unfrequently seen osteo-myelitis occurring in connection with amputation and compound fracture, and attended with but little pain, apparently for the reason just mentioned. In one case of gunshot fracture of the thigh which went on to a fatal conclusion, there being but very little pain in any part of its course, it was found, on making the autopsy, that although there was extensive suppuration of the medullary tissue, the pus could readily escape from the medullary canal at the place of fracture, and from the limb itself through the track of the wound made by the projectile.[1] There was, therefore, but little chance for purulent matter to become imprisoned within the unyielding walls of the bone, and thus the symptom of pain was almost entirely avoided. But candor compels the author to state that he has occasionally seen cases of suppurative osteo-myelitis accompanied with only a trifling degree of pain, wherein he was unable to assign any satisfactory cause for the absence of that particular symptom which in many instances is the most prominent of all. Further investigation is necessary for the elucidation of this point.

Again, *the pain*, and other symptoms of osteo-myelitis, after having been very severe for a considerable length of time, *may suddenly cease on the appearance of a small circumscribed swelling, containing pus, in the soft parts near the spot where the pain was most intense.* In such cases spontaneous perforation of the bone occurs, and the purulent matter escaping from its place of confinement within the bone, produces an abscess of the neighboring soft parts. This is precisely what happened in a case reported by Mr. Hey, No. XXI. of this essay, in another related by Mr. Stanley, No. XXXVIII., and in another recorded by Mr. Pott, vide Case No. VIII.

Finally, a critical examination of the subject shows that in most cases of acute osteo-myelitis, the symptoms bear a pretty constant relation to each other. The pain appears first, and is followed in a short time by heat and swelling, with more or

Order of symptoms.

[1] Vide Case X.

less reddening of the surface, at the seat of the disease. This relationship of the symptoms, however, does not always obtain; for it sometimes happens that although the osteo-myelitic pain is very intense, and the morbid process very acute, several days elapse without the production of the other local symptoms of phlegmasia, namely, heat, redness, and swelling. The following case, which occurred in the author's practice, affords a good illustration of this important clinical fact.

CASE XXVII. *Gunshot Wound involving Inner Condyle of Right Femur; Secondary Arthritis of a Severe Character occurred Ten Days afterwards; Amputation at Junction of Middle and Inferior Thirds of Thigh; Death by Secondary Hemorrhage on the Fifteenth Day after that; Suppurative Osteo-myelitis discovered at the Autopsy.* — Private James N. Saxon, Co. D, 9th Louisiana (Confederate), aged 27, and of good constitution, was admitted to the Stanton U. S. Army General Hospital, November 9, 1863, from the field. He had been wounded and captured November 7, in the action at Rappahannock Station.

On examining him, it was found that a conical musket bullet had penetrated his right knee from the front, about three inches above the patella, on a line with its inner margin, and passed downwards, backwards, and a little inwards so as to escape from the calf of the leg, at its inner side, about six inches below the flexure of the knee-joint. The bullet passed through the internal condyle of the femur, fracturing it with comminution. The knee was bent when the wound was inflicted. The wound itself was but moderately inflamed. The period for the performance of primary amputation having already gone by, it was thought to be expedient to apply simple dressings to the wound, to keep the patient quiet in bed, and to await the progress of events, or, in other words, to treat the case expectantly.

Gunshot wound of knee.

Nothing untoward happened until November 17. Then secondary inflammation of the knee-joint, severe in character, suddenly supervened. The patient took a heavy chill. The knee speedily became much swelled, hot, very painful and tender. The periarticular tissues of the knee and the areolar tissue of the lower part of the thigh also became extensively infiltrated with serum. He had great constitutional disturbance; skin hot and dry; tongue coated white; pulse 120; no appetite, but much thirst; countenance anxious, and he was very restless. On the next day (November 18), his limb was amputated by the double-flap method at the junction of the middle and inferior thirds of the thigh by the author, anæsthesia having been produced by the administration of sulphuric ether. There was well marked œdema at the place of operation. The stump was dressed with several points of interrupted suture, together with strips of adhesive plaster, and a supporting bandage was carefully applied. He reacted promptly after

Amputation of thigh.

the operation. Subsequently almost all of the stump united by the first intention. He did well in every respect until December 1. On that day he complained of having a *great deal of pain in the stump*. He was also agitated and restless, but did not have any fever. The stump was neither swelled nor hot. On the 2d he complained that the *pain* was still *more severe*, and he *referred it to the stump-bone*, especially the end thereof. He appeared to be still more agitated and restless, and his countenance indicated much suffering. He was not feverish, and the stump was not swelled nor hot. He was very restless through the night. On the morning of the 3d, at an early hour, the ligature separated from the femoral artery, and *secondary bleeding in a great stream* immediately supervened. The hemorrhage was soon arrested by digital compression of the femoral artery, and did not recur; but the patient had lost so much blood before this was effected, that he could not be made to rally afterwards, and he died in the afternoon, eight hours subsequent to the separation of the ligature and the occurrence of the hemorrhage.

Secondary hemorrhage.

Autopsy. — On opening the stump freely by incision, it was found that all of it had united firmly by adhesion, except a small part about and in front of the end of the stump-bone. There was a small flattened abscess containing laudable pus in the substance of the anterior flap, and the muscular tissue surrounding it presented a dark-brown color to the depth of one or two lines. The end of the femoral artery was patulous, not contracted, and did not exhibit any evidences of an effort on the part of the reparative processes to occlude it. It was embraced between the forked extremity of a remarkable osteophyte which, springing from the linea aspera near the end of the stump-bone, extended horizontally inwards along the angle of junction of the flaps, at their base. This new osseous growth had a reddish color and a very porous structure. It was about two and one half inches long by three fourths of an inch in breadth and one fourth of an inch in thickness. A branch of considerable size was given off from the artery about half an inch above the place of ligation. The end of the femoral vein was well sealed up. The interior of the stump was not sloughy in any part of it. The periosteum investing the stump-bone, for several inches above its end, was redder than natural, and thickened. On removing a section from the lower end of the stump-bone four and a half or five inches long, and splitting it lengthwise with a saw, it was found that the medullary tissue was inflamed. Each surface of the section exhibited a considerable number of isolated small-sized abscesses located in this tissue. These abscesses presented a grayish-white, steel-gray, or skim-milk color, and varied in size from a pin-head to a split pea. The medullary tissue intervening between the abscesses presented a dark-red color, and was hepatized.

Abscesses in bone.

The internal organs were exsanguinated, but, in other respects, healthy.

Comments. — This patient had intense pain in the stump-bone for about three days, without the occurrence of symptomatic fever, or any swelling, redness, and unnatural warmth of the stump itself, when his life was suddenly terminated by secondary hemorrhage. It is of course impossible to conjecture how much longer the pain might have continued without the development of the other symptoms of phlegmasia. Moreover, the pain increased in severity from one day to another. On the first day the pain was intense, and accompanied by restlessness and nervous agitation. On the next day it became agonizing, his countenance expressed great suffering, and he was still more restless and agitated; and the pain and nervous disturbance continued to increase until the great hemorrhage, which caused his death, occurred on the following morning. The presence of osteo-myelitis, however, was not even suspected, till it was discovered on making the post-mortem examination. Although, as already stated, the stump was very painful, and the bone appeared to be the principal seat of the distress, the greatest part of it had already united by the first intention, and it was not swelled, nor red, nor hot. At the same time there were no febrile symptoms whatever. It was, then, this entire absence of heat and swelling in the stump, and of constitutional disturbance in the shape of fever, which caused us to completely overlook the significance of the local pain and the general nervous agitation as symptoms indicating the presence of osteo-myelitis in a severe form.

Osteo-myelitis not suspected.

The new bony growth (osteophyte) which was found in the stump at the autopsy, had been formed very rapidly (in less than two weeks), was also large in size, singular in shape, and altogether remarkable in appearance. The formation of new osseous tissue *external* to the periosteum, and apparently from the common cellular or connective tissue, in consequence of osteo-myelitis, is worthy of attentive study, and accordingly will be discussed when we come to speak of the results and complications of that disease.

Osseous tissue formed from connective.

The variety of secondary hemorrhage which destroyed this patient's life, introduces a very important and interesting subject to our notice. It has, however, no direct relation with our present theme, since it appears to have been only accidentally connected with a case of osteo-myelitis, and therefore cannot with propriety be discussed in this place.

This case also gives us some reliable information upon a point which is closely connected with the main subject of the present discussion. It has been asserted by some that acute suppurative osteo-myelitis and pyæmia are so nearly related, and resemble each other so closely, that in a large number of instances the one cannot be distinguished from the other; that this form of osteo-myelitis is, in reality, a result of the pyæmic intoxication; that the collections of pus in the medullary tissue which appear to be produced by inflammation of it, are, in truth, only secondary in character, and strictly analogous to the so-called secondary abscesses of the lungs, liver, spleen, muscles, and joints, which are generally believed to be produced by pyæmia; and, in short, that pyæmia is, in reality, the disease which so often occasions the development of purulent depots or abscesses in the marrow, after injuries and surgical operations involving bone. This theory, at first sight, certainly appears very plausible; but the higher question as to its soundness and truth must afterwards present itself for consideration. Here the clinical history and the autopsy of the case just related, furnish us with valuable evidence. This patient sustained a secondary amputation of the thigh on account of gunshot injury, and fifteen days afterwards suddenly lost his life from hemorrhage. On examining the stump-bone after death, the medullary tissue was found to be hepatized and to contain a number of small isolated abscesses. But the clinical history shows that he did not have pyæmia, and that he did not exhibit even one of the symptoms belonging to said disease. It shows further that he suffered very much from one of the symptoms belonging to osteo-myelitis, for about three days before death. Here, then, a case is presented to us of purulent depots in the marrow, which unquestionably were not occasioned by pyæmia. Here, then, is an example of traumatic osteo-myelitis which had already reached the stage of suppuration, and was still entirely unconnected with pyæmia. Here, then, it is proved that acute suppurative osteo-myelitis is a disease entirely distinct from pyæmia, although the former not unfrequently produces the latter, as we have already seen.[1]

Relations of osteo-myelitis to pyæmia.

Pyæmia did not exist.

But it is necessary to return to the consideration of the symptoms of osteo-myelitis. Of these, severe pain located in the bone at the seat of the disease, is one of the most constant and important. It is present in all the cases where the continuity of the morbid bone is preserved, and likewise in a large

Recapitulation of symptoms.

[1] Vide Cases I., II., X., XIII., XV., etc.

share of those where the continuity is destroyed, and the medullary canal laid open by fracture, by amputation, or by resection. It is observed in both the acute and the chronic forms of the disease. The bone-pain is generally severe and aggravated at night, but this is not always the case. In nearly every instance the local pain precedes all the other symptoms of osteo-myelitis. It is almost always present, unless the medullary canal, at the seat of the disease, happens to be open in such a way as to allow the ready occurrence of tumefaction in the inflamed medullary tissue, and the ready escape of purulent matter as soon as it is formed, and unless the sensibilities of the patient are blunted by the hebetude of typhoid disease. In the acute forms of osteo-myelitis, the local pain is followed by fever, for the most part of an irritative type. The fever supervenes after an interval varying in length from a few hours to several days. Not unfrequently the febrile movement runs very high, and is accompanied by delirium. In the chronic forms of the disease, surgical fever, as a general thing, is either entirely absent, or occurs only in paroxysms, or at the periods of exacerbation on the part of the disease, which are produced, in great measure, by adventitious circumstances. In the acute forms of inflammation of the medullary tissue, the febrile symptoms are generally accompanied by more or less swelling of the soft parts at the seat of the disease, with tenderness under pressure, and abnormal warmth of the tissues in the same locality. The skin investing the seat of the disease is generally somewhat redder than natural, or slightly reddened in color. Occasionally the reddening is intense, and the local warmth has a pungent character. Not unfrequently, however, especially in the strumous and the other non-traumatic varieties of the disease, the skin investing the morbid part is paler than natural, and presents a doughy appearance. Concerning the character of the swelling which is produced by acute osteo-myelitis, it should be remarked further that it is generally œdematous, and pits under pressure; that it is also, for the most part, flattened (*i. e.* not pointed) in shape, and coincides in extent with the limits of the disease itself. Chronic osteo-myelitis is likewise accompanied by local swelling, heat, and tenderness. The swelling is often œdematous; but the tumefaction is not unfrequently rendered still more considerable by chronic enlargement of the diseased bone itself, and by chronic thickening of the soft parts which invest it. Chronic osteo-myelitis frequently produces necrosis of the diseased bone; and, in such cases, the presence of dead bone generally affords useful information with regard to the real character of the

morbid process. Chronic osteo-myelitis is often accompanied by a carious and an osteo-porotic condition of the osseous tissue. The consideration of this fact, however, properly belongs to another portion of this essay.[1]

Diagnosis of Osteo-myelitis. — The *diagnosis* of this disease, when it presents itself in an acute form, is not made, in a good many instances, until the lesions it produces are found on examining the body after death. Such a result obtained in the case last related. Mr. Holmes says, osteo-myelitis is more frequently recognized in post-mortem examinations than at the bedside of the patient.[2] Perhaps this statement is exaggerated; but whether it is or not, there is no doubt, in the opinion of the author, that oftentimes the presence of this disease is not recognized, from inattention to, or want of knowledge of, the subject on the part of the surgeon. There is no doubt that heretofore the study of this disease has not been sufficiently attended to by the great mass of surgeons in both Europe and America, and that, in consequence, its existence has not been detected at the bedside of the patient in many instances where it would have been if adequate attention had been given to the subject. The professors of surgery in our medical schools do not discuss this disease in their lectures. The text-books on surgery in general use in this country do not contain any account of this disorder, with the exception of those written by Dr. Gross and Mr. Erichsen, and their description is very brief, meagre, and incomplete. Most of the works on military surgery are equally silent on this topic. It is therefore a disease which surgeons in general have not been prepared to treat, and consequently have not been expecting to see. We should not be surprised, then, to find that they have not unfrequently overlooked it when they have met with it, and have considered it to be a disease of very rare occurrence, when in reality it is not so.

Not generally recognized *ante mortem*.

Imperfectly studied.

Besides, there are certain intrinsic difficulties which lie in the way of diagnosing this disease. In the first place, it involves a structure which is deeply seated, encased with bone, oftentimes also covered over with a thick mass of muscles, and therefore correspondingly hard to subject to surgical examination; and, in the second place, the more obvious manifestations of inflammation, and the swelling produced by the same violence or wound which pro-

[1] See Chapters on Ostitis and Caries further on in this Section.

[2] *System of Surgery*, vol. iii. p. 628.

duces the osteo-myelitis in cases of a traumatic origin, not unfrequently serves to mask, or withdraw the surgeon's attention from, the mischief in the medullary tissue.

Only pathognomonic signs.

The only signs which can be considered as truly pathognomonic of osteo-myelitis, are the reddened and sclerosed or hepatized appearance of the marrow itself, with perhaps some drops of pus oozing from it, which are sometimes detected by ocular examination.[1] But the clinical observation of these signs is practically restricted to the cases where osteo-myelitis follows amputation, with the addition perhaps of some instances of resection. In view of the importance of these signs as helps to a correct diagnosis, it is advisable for the surgeon to open the stump and examine the condition of the marrow in all cases where there is good reason to suspect the presence of that disease after amputation, especially if the form of it be acute. If the flaps are not united, there can be no objection to this proceeding; and even if they are grown together, the amount of cutting usually required to expose the end of the stump-bone, does not oppose any considerable obstacle to the patient's recovery.

But with regard to osteo-myelitis produced by compound fracture, by contusion and contused wounds, by scrofula, by syphilis, by rheumatism, and indeed by any cause besides amputation, with the unimportant exception already mentioned, there is no one symptom which can be considered as diagnostic of the disease. In all these cases, which, taken together, constitute a large majority, the diagnosis can be established best by a proper appreciation of the symptoms taken in *totality*. To accomplish this end, it is necessary that each symptom should be rigidly interpreted, and that the method of exclusion should be employed. If the case last related (No. XXVII.) had been investigated in this way, the diagnosis would have pretty certainly been made. For example, in that case the principal symptom was intense pain, which seemed to the patient to be located in the bone. Now, this pain was not neuralgic, because it was not intermittent, and did not shoot along the course of any of the nerves; it was not produced by acute periosteal abscess, or by diffuse cellulitis, because there was no swelling of the stump: it therefore must have been produced either by inflammation of the osseous or the medullary tissue, by ostitis or osteo-myelitis. Pathological anatomy teaches us that primary ostitis occurs but very seldom in connection with amputation, while osteo-myelitis occurs very often in that connection. In this

Primary ostitis.

[1] Vide Cases I. and XXIV.

way the inference would have become irresistible, that the pain, in this case, was, in all probability, produced by or connected with inflammation of the medullary tissue of the stump-bone.

The loosening or detachment of the periosteum, with the presence of pus between it and the bone, conjoined with deep-seated local pain, heat, swelling, and great constitutional disturbance, denotes that the patient has either acute periosteal abscess or osteo-myelitis.

If, on making an evacuative incision, globules of oil are found mixed with the pus which is discharged, then the opinion just expressed with regard to the seat of the disease, becomes considerably strengthened. If after the tension of the soft parts has been relieved, and the pus has been evacuated, by suitable incisions, the bone-pain still continues, then the presumption becomes strong that the medullary tissue also is inflamed.

The only diseases for which acute suppurative inflammation of the marrow is liable to be mistaken, are diffuse inflammation of the cellular tissue, otherwise called phlegmonous erysipelas and acute periosteal abscess. It can be distinguished from diffuse cellulitis, sometimes, by the shape of the swelling alone, which in osteo-myelitis is bounded or circumscribed by an abrupt rim or border,[1] corresponding with the limits of the diseased medullary tissue,[2] and in diffuse cellulitis does not terminate in that way. It can also be distinguished from the last named affection by the loosening or detachment of the periosteum, with the presence of exudation or purulent matter between it and the bone, which is often found in the former disease, but never in the latter, on making an incision down to the bone. Explorative incisions, therefore, not unfrequently furnish important aid in making the diagnosis of these diseases, and for that reason they should not be neglected. Such incisions, especially if they are freely made, not only assist us to make a correct diagnosis, but also are of much value in the treatment of both osteo-myelitis and diffuse cellulitis; and therefore the surgeon should have no hesitation about employing them freely, and making them also of sufficient size. Upon this subject M. Chassaignac substantially says, "In our studies upon diffuse phlegmon (diffuse cellulitis or phlegmonous erysipelas), we have

Explorative incisions.

[1] Vide Case XX.

[2] The "puffy tumor" of the scalp described by Pott, gives an excellent idea of the features of the tumefaction which characterizes acute suppurative osteo-myelitis. There is but little similarity between it and the diffused swelling produced by phlegmonous erysipelas of the scalp. In some cases of osteo-myelitis occurring in the extremities the swelling is so characteristic of the disease that it may be looked upon as the puffy tumor developed on an enlarged scale.

Puffy tumor of scalp.

established, as a fundamental principle, in the therapeutics of that affection, that the tegumentary incisions should never be stopped short of laying the aponeurosis bare." He adds that, if the color of the deep fascia is found to be at all changed, said membrane ought to be incised upon the spot. This precept is perhaps of the highest importance in a case of osteo-myelitis where the existence of that disease is only suspected, since, thanks to this sign which must be considered as characteristic of osseous suppuration in this malady, the surgeon who can believe in the simple existence of diffuse cellulitis, is able to know at the same time that he has to deal with a grave osseous lesion, with either osteo-myelitis or with diffuse periosteal abscess. In all the cases of osteo-myelitis which we have observed, we have found the enveloping aponeurosis tinged or discolored, sometimes in spots and sometimes in its whole extent, with a greenish hue, which has led us to incise it, and to ascertain the presence of a sub-aponeurotic pus, with drops of oil, very characteristic of the disease, situated either within the interior or upon the exterior of the affected bone. Moreover, this sub-aponeurotic pus does not always present, as its sole characteristics, the abundance of the serosity which dilutes it, and the presence of drops of oil; it sometimes exhibits a strongly marked russet tint.[1]

Discoloration of aponeurosis.

Russet tint of pus.

But if, for any reason, it be deemed inexpedient to make exploratory incisions for the purpose of verifying the diagnosis, much valuable information may be obtained by using an exploring needle. In cases where the periosteum is detached and separated from the bone by a quantity of pus, if such a needle be thrust into the swelling in a direction towards the bone, and it be attempted to move it in circular sweeps, an equable resistance will be found as long as it remains in the soft parts; but if it be thrust down to the bone, and then drawn back a little (about a line), its point may be turned in any direction within the abscess.

Exploring needle.

If, when purulent matter has been withdrawn from deep-seated parts, either by incision, or by means of a trochar and canula, or by spontaneous discharge, there be doubt as to whether its development is connected with disease of the osseous tissue, the question may, not unfrequently, be put to rest, by finding, in the pus, particles of disintegrated bone resembling fine sand, which, on examination with the microscope, are found to contain canaliculi, lacunæ, and Haversian canals, and by also finding in the purulent matter, on the application of chemical tests, the calcareous salts belonging to bone, in at least considerable quantity.

Calcareous sand.

[1] Vide *Traité Pratique de la Suppuration*, t. i. p. 474.

Acute suppurative osteo-myelitis may sometimes be distinguished from acute periosteal abscess by another sign besides the non-alleviation of the pain after making evacuative incisions, which obtains if the first named disease is present. This additional sign is founded on the condition of the bone which underlies the suppurating periosteum. This portion of the bone is necrosed in such cases, and oftentimes the extent of the necrosis is very great. Now if the death of the bone have been occasioned by osteo-myelitis, and the suppuration of the periosteum and the neighboring parts be secondary in character, and produced by extension of the inflammatory process to them from the diseased marrow through the relationship of contiguity, then the surface of the dead bone is apt to present a rough, eroded, or worm-eaten appearance, on account of the adherence of living particles and granules of osseous tissue to the periosteum, at the time its separation or detachment from the dead osseous tissue occurred; but if the necrosis be primarily occasioned by diffuse periostitis, then the surface of the dead bone is found to be comparatively smooth, the longitudinal furrows are perhaps somewhat wider and deeper than natural, but the circumferential laminæ are not eroded nor excavated; for, under such circumstances, the portion of the bone which dies first, is that which lies next to the inflamed periosteum. The surface of the dead bone looks as if the diseased periosteum had been suddenly peeled off from it.

Surface of bone porous.

If, however, necrosis of a bone in its entire thickness is produced by coexistent and coextensive inflammation of both the marrow, the periosteum, and the osseous tissue itself, as occasionally happens, then the surface of the dead bone is apt to be smooth. The freedom of the surface of the necrosed bone from roughness under such circumstances denotes that the circumferential laminæ have been deprived of vitality through separation or detachment of the periosteum from the osseous tissue, on account of disease of the deep layers of the periosteum itself, and consequent arrest of the supply of blood necessary to nourish the circumferential osseous laminæ, and keep them alive.

Exceptional cases.

But, while we are endeavoring to establish the diagnosis truly in a case of suspected osteo-myelitis, it is important that we should consider the *tout-ensemble* of the morbid phenomena, or give attention to the symptoms taken as a whole; and, while doing it, the method of exclusion can be advantageously employed. By pursuing substantially this course, we were enabled to make a

diagnosis in Case No. X., although *one* of the most important signs of suppurative inflammation of the medullary tissue was absent, and *none* of them were strongly marked.

Diagnosis of chronic form more simple.

The diagnosis of osteo-myelitis in its *chronic forms*, is, in general, not difficult to make. The clinical history of the case, the length of time it has lasted, the order in which the morbid phenomena have been developed, the bone-pain, the local heat and swelling, together with the suppuration of the neighboring soft parts, and, in patients where the disease has followed a solution in the continuity of the bone occasioned either by accident or by surgical operation, the frequent occurrence of necrosis along with the development of new osseous tissue, sometimes in large quantity, from the detached periosteum and from the part of the bone which has not lost its vitality (both of which can, in most cases, be detected with but little difficulty), the persistent suppuration of the parts contiguous to the sequestrum produced by the mechanical irritation occasioned by its presence, and perhaps the exfoliation from time to time of small fragments of necrosed bone, do not leave us long in doubt with regard to the real nature of the disease and the tissue from which it originally sprung.

Pathological Anatomy of Osteo-myelitis. — The morbid conditions of the marrow in respect to structure, which may be produced by the inflammatory process, are at least threefold, namely, 1st, *carnification or hepatization;* 2d, *suppuration;* and 3d, *gangrene.*

1. *Of the Carnified or Hepatized Marrow.*[1] — Among the earliest and most constant of all the effects produced by inflammation of the medullary tissue is reddening of its hue, accompanied by an increase of its density and tenacity. The color of the marrow during this, which may, with propriety, be called the first stage of osteo-myelitis, is not the same in all cases. It has been found to vary from *yellowish* or *coppery red*[2] to *bright red*,[3] to *brown*,[4] and almost to *black*.[5] In this form the inflamed marrow is said to be carnified or hepatized on account of some similitude which it is supposed to bear to red muscular tissue or flesh, on the one hand, and to dark-red, reddish-brown, or brown hepatic tissue, on the other. Moreover, the terms carnification and

Color of carnified marrow.

[1] Pirogoff, the distinguished Russian military surgeon, speaks of red hepatization of the medullary tissue as one of the consequences of the inflammatory process.

[2] Vide Plate V. [3] Vide Plate I. [4] Vide Plate VI. [5] Vide Plate III.

hepatization are not new inventions in the domain of pathological science, and therefore will be likely to prove all the more acceptable when employed in the present connection.

It has already been stated that the healthy medullary tissue has a yellowish color and a soft consistence in the long bones during the adult period of life. Now, when this tissue is subjected to the operation of the inflammatory process, its color becomes changed, because its histological structure is altered by that process. Its hue becomes reddened, in the *first* place, because the inflammatory irritation causes its fat to disappear with great rapidity; in the *second* place, because, while this is going on, the same irritation causes the very rapid production of microscopic marrow cells, most of which are free and granular, often highly so, presenting no inconsiderable resemblance to what were formerly called exudation corpuscles; and, in the *third* place, because the inflammatory irritation, either *per se*, or indirectly by the histological transformations which it produces, causes an increased afflux of blood to the affected part, and thus occasions a hyperæmia (congestion) of the diseased medullary tissue. That the marrow, when affected with osteo-myelitis, contains more than the normal quantity of blood, is proved by the fact that, on being wounded under such circumstances, it is apt to bleed freely.[1] The author, also, has often observed, while performing secondary amputation in the continuity of the limbs, no inconsiderable tendency to troublesome bleeding on the part of the medullary tissue involved in the operation, when it happened to be inflamed, but not otherwise.

Cause of change of color.

When the carnified marrow has a yellowish-red or a copper-colored hue, it is because fat vesicles in considerable quantity still constitute one of the histological elements. As muscular tissue acquires a yellowish tinge from undergoing the fatty degeneration, so the inflamed medullary tissue may still retain some of that same tint, because the oil has not yet been absorbed from it to such extent as to cease to perceptibly affect its color. Other things being equal, the greater the proportion of the fat (not free) contained in the inflamed medullary tissue, the deeper the yellow tint is found to be on examination. But the deep-red, the brown, and even the dark-brown color of the carnified or hepatized marrow does not afford any certain evidence that the fatty histological element has been entirely withdrawn from it; for the microscopical examination in such cases shows that, although the proportion of fat vesicles is generally very much diminished, still they have not entirely dis-

[1] Vide Case XIX.

appeared, nor entirely ceased to enter into the composition of the diseased tissue. Such, at least, has uniformly been our experience in studying the specimens of osteo-myelitis in the first stage occurring in adults, and in the long bones for the most part. We have not yet had an opportunity to study the histological features of osteo-myelitis occurring in childhood.

But the extent to which the quantity of blood in the inflamed medullary tissue is increased by the morbid action, or, in other words, the amount of the hyperæmia (congestion), has also an important bearing upon the subject of the morbid coloration of this tissue. Its influence is seen to be strongly marked in producing the varieties of hepatized marrow (not gangrenous) which are almost black in color.[1] When the hyperæmia is very great, it not unfrequently happens that one or more of the capillary vessels becomes ruptured, and an extravasation of blood takes place, whereby a true *apoplexy* of the marrow is produced. These apoplectic extravasations are sometimes confined to one spot;[2] but in other instances they occur in many points at the same time. Sometimes they bear considerable resemblance to ecchymosis; and if the osteo-myelitis have been occasioned by contusion, there may be some doubt as to whether the extravasation of blood has been occasioned by intense congestion or by violence.

Apoplexy of the marrow.

We will next proceed to inquire as to what changes in anatomical structure the hepatized and carnified conditions of the marrow owe the increased density and toughness which they may acquire through the operation of the inflammatory process.

This sclerosis of the marrow seems to be produced firstly by the development, under the stimulus of inflammatory irritation, of a rudimentary fibrous material, represented when examined with the microscope, for the most part, by spindle-shaped fibre cells in various stages of elongation and evolution. Sometimes plasmatic cells, also, are seen. But this new production of fibrous tissue has generally seemed to me insufficient in quantity to account satisfactorily for the increased consistence of the diseased marrow. In more than one instance it has appeared to me that the increase of the former had entirely failed to keep pace with that of the latter, and consequently that the former bore but a small proportion to the latter. Hence I have been compelled to seek, at least by conjecture, for some other cause which may assist in producing the induration and tenacity peculiar to some cases of

Sclerosis of the marrow.

[1] Vide Plate III.

[2] Vide case of Pool, No. XLIV.

the carnified or hepatized marrow. And why may not such assistance be afforded by sclerosis of the intercellular substance proper, that is, the substance which lies between the free marrow cells, and connects them together? It seems to me not improbable that inflammatory irritation, provided the grade of said irritation is not too intense, does produce such a hardening of the intercellular substance, sometimes also called the basis-substance, of the medullary tissue, as one of its normal results, and as one of the first in the series of transformations which the histological elements of the medullary tissue may undergo through the agency of the inflammatory process.

To these two causes, namely, development of new fibrous matter on the one hand, and sclerosis of the intercellular substance proper on the other, we must principally attribute the induration and toughness which attend the carnified conditions of the marrow.

Medullary tube obliterated.

Again, the first stage of osteo-myelitis is not unfrequently accompanied by the formation of new osseous tissue in the medullary tubes of the long bones and in direct relation with the diseased marrow. Cases X., XI., and XLIV. afford well marked examples of it. The quantity of the new osseous growth may be so great as to completely plug up the medullary tube. It is reddish in color, and usually very porous in structure from the large size of its medullary spaces (cancelli). It unquestionably has its origin in the inflamed medullary tissue, and is very probably produced by a direct transformation of that tissue. Virchow states that when the medullary tissue is about to be converted into bone, the nature of its basis or intercellular substance alters. It becomes firmer, more cartilaginous, and the individual cells appear to lie in largish cavities. Gradually they become jagged, from sending out little processes, and then nothing more is required than that calcareous salts should deposit themselves in the basis-substance, *i. e.*, that the sclerosed intercellular substance should become calcified, and the new osseous tissue is complete.[1] The same writer also says that in just the same manner as the cartilage cell may become a bone corpuscle, the marrow cell also may become a bone corpuscle, and that the process by which the medullary tissue becomes transformed into bone, is strictly analogous to that by which cartilage undergoes the same transformation.

The formation of new osseous tissue out of carnified or hepatized marrow appears to be in the main a conservative process, and

[1] Vide *Lectures on Cellular Pathology*, p. 466.

A conservative process.

likewise to denote that the inflammatory irritation is not very intense at the time and place of such formation.

The union of fractured bones, and the sealing up of the ends of stump-bones after amputation, is attended with a reddened state or *hyperæmic* condition of the marrow, and the transformation of the medullary tissue into bone appears to perform an important part in the osteo-genesis required for the repair of that class of injuries. But in such instances the formation of new osseous tissue is, for the most part, a purely physiological process, certainly not a morbid one. We therefore find in nature both a physiological and a pathological hyperæmia of the marrow. These two conditions are closely allied, and both are active in character. The one results from simple, and the other from inflammatory irritation. They seem to differ mainly in the degree of their activity, and appear to have the capacity of running the one into the other, under favoring circumstances. Oftentimes the physiological can be distinguished from the pathological hyperæmia of the marrow only by the clinical history of the case. The clinical history of the patient is always a matter of the first importance, and we should be careful to never overlook it in our zeal for pathological anatomy.

Physiological occlusion of medullary canal.

The next case is taken from the author's practice, and affords us an example of osteo-myelitis in the first stage, which terminated fatally from pyæmia.

Case XXVIII. *Primary Amputation at Right Knee-joint for Gunshot Injury; Death from Pyæmia Nine Days after the Operation; Medullary Tissue of Femur red in Color, actively congested and carnified; Secondary Abscesses in the Lungs.* — Private Eldridge Rathburne, Co. C, 36th Wisconsin Vols., aged 19, was admitted to the Stanton U. S. Army General Hospital, June 4, 1864, on account of a recent exarticulation of his right leg at the knee-joint by the flap method. He stated that he was wounded May 31st, near Old Church, Va.; that the operation was performed on the same day by Dr. Hayward, chloroform being employed as an anæsthetic; and that his general health was impaired at the time.

June 6. It was observed that the stump was in a sloughy condition,

[1] Ollier, in his experiments on animals, has succeeded in producing new bone from the marrow by irritating it *in situ*; but he found that the degree of irritation must not be too great, for, when it is excessive, the marrow breaks down into pus, there being in fact no tissue more disposed to purulent transformation. (See *American Journal Medical Sciences*, January, 1868, p. 148.) Again, M. Ollier has observed that traumatic irritation of the marrow may cause ossification of that structure, though it is more apt to produce suppuration. (*Op. cit.*, p. 151.)

and that he was failing rapidly. Prescribed tonics such as ferri et potass. tart. grs. v. ter in die, and quiniæ sulph., together with nutrients and alcoholic stimulants in liberal quantity.

June 9. He died of pyæmia.

Autopsy twelve hours after death. On examining the stump, and opening the medullary canal of the femur, the medullary tissue was found in a condition of active hyperæmia, having a bright-red color, and no appearance of fat about it. In respect to consistence, it was firmer and stronger than natural, or carnified. The lungs contained a number of visceral abscesses. The presence in this case of osteo-myelitis in the first stage, not only of pyæmia, but also of the so-called secondary abscesses of the lungs, is a clinical fact of some importance, and should not be overlooked.

2. *Of Suppurative Osteo-myelitis.* — Suppuration, or the formation of pus in the medullary tissue, is a pathological condition which is not unfrequently superadded to the carnified or hepatized marrow. As, in the progress of pneumonia, it happens that, if the inflammatory irritation in the hepatized pulmonary tissue does not subside, and a resolution of the products of the inflammatory process does not take place, the inflamed pulmonary tissue is almost certain to suppurate, even so in the progress of osteo-myelitis, if the inflammatory irritation in the hepatized marrow does not subside into a simple formative irritation, or cease altogether, the inflamed medullary tissue is very apt to suppurate. The formation of pus in the marrow appears to be preceded always by hepatization or a kindred pathological condition; at least, the author has always found abscesses of the marrow to be surrounded by hepatized or carnified tissue. Suppurative osteo-myelitis may therefore be called the second stage of the disease. In it the inflammatory process appears to be more active and more uncontrollable than in the first stage. This is proved by the clinical history of such cases, as well as by the disorganization of the marrow which is revealed by post-mortem examination.

Suppurative osteo-myelitis.

Second stage.

If one of the long bones, such as the femur or tibia, be involved with suppurative osteo-myelitis of a recent date, and it be split lengthwise with a saw, on cleaning off the surfaces of the section, the marrow is often found to present the following appearance, namely, the carnified or hepatized tissue is seen to contain a number of small isolated abscesses, varying in size from a mustard-seed to a pea, and having a color like that of skim-milk, or like that of pure milk, or cream, or lemon-peel, and not unfrequently these abscesses have a greenish yellow hue.[1] But if the examination is

[1] Vide Cases I., II., XXIV., XXVII., etc.

made at a later period, it may be found that the hepatized marrow contains one abscess of large size and irregular shape, produced apparently by the coalescence of several smaller ones.[1] If the bone is examined at a still later period in the history of the disease, it may be found that the medullary tube is filled with pus through a great space, that the medullary tissue is destroyed to the same extent, and that the bone itself is necrosed to about the same extent.[2]

Ending in the preparative process.

Hepatization and suppuration of the medullary tissue are not distinct forms of osteo-myelitis, but only successive phases of the same morbid process, only successive steps in the series of transformations which the histological elements of the marrow may undergo through the agency of inflammatory irritation.[3] We have already seen how the inflamed medullary tissue acquires a red color and increased consistence, that the inflammatory process speedily deprives it of a good portion of its fat, causes a rapid development of new cell-formations, produces sclerosis of the intercellular or basis substance, and at the same time occasions hyperæmia. If the irritation be moderate in degree, this new medullary growth becomes transformed directly into new osseous tissue, and in that way the force of the disease may be expended. But if, on the other hand, the inflammatory irritation become more severe in degree, this new medullary growth becomes transformed directly into pus, thus producing abscess of the marrow; and if it be very severe or intense, it destroys the vitality of the portion so affected outright, and occasions gangrene thereof.

Ending in the destructive process.

The transformation of this new medullary growth, inflammatory in its origin, into pus appears to be attended with the following phenomena: the free medullary cells, already granular, multiply themselves with very great rapidity, and become more granular still, while, at the same time, the intercellular substance softens, and soon liquefies; the descendants of the preëxisting marrow cells thus become converted into pus corpuscles, and the intercellular or basis-substance into liquor puris, or the liquid intercellular material of purulent matter. On this point Virchow says, —

1 Vide Cases X. and XXIX., and Plates II. and VI.

2 Vide Case VI.

3 The close relationship between hepatization and suppuration of the marrow is well illustrated in a general way by Case XXV. In that case the portion of the marrow which corresponded with the necrosed bone was broken down and infiltrated with pus, or, in other words, it was the seat of suppurative inflammation. Above the part named, the medullary tissue was red, and more than usually firm (carnified); and still higher up it presented a natural appearance: so that, on proceeding from above downwards, we meet first with healthy marrow, next with osteo-myelitis in the first stage, and last with that disease in its second stage, the stage of suppuration.

"The pus is here no special product, separable from the other products of proliferation and formation; it is certainly not identical with the pre-existing tissues, but its origin can be directly traced back to the elements of the preëxisting tissue. It is not produced by any special act, by any creation *de novo*, but its development proceeds from generation to generation in a perfectly regular and legitimate manner." [1]

Pus not created *de novo*.

In connection with another branch of the same subject he also tells us: —

"The transformations are here so gradual, that the pus which is in immediate contact with the granulations, constitutes, as is well known, a more mucous, stringy, and tenacious matter, which really contains mucine like the granulation tissue, and only when we proceed farther outwards, exhibits the properties of completely developed pus. The perfect pus of the surface gradually passes, as we descend, into crude pus, the mucous, tenacious, immature pus of the deeper layers, and what we call *maturation* depends simply upon the gradual conversion of the mucous intercellular substance of the originally tenacious pus, which is allied in structure to granulations, into the albuminous intercellular substance of pure pus. The *mucus* dissolves, and the creamy fluid is produced. *The maturation is therefore essentially a softening of the intercellular substance.* So direct is the connection which subsists between development and retrograde metamorphosis, between physiological and pathological conditions." [2]

With regard to the nature of the granulation tissue of which Virchow speaks above, let him give his own ideas in his own words. He says, —

Granulation tissue.

"When we examine granulations for the purpose of comparing them with medullary tissue, we find that no two descriptions of tissue more closely correspond. The marrow of the bones of a new-born infant could at any time, both chemically and microscopically, be passed off as granulation tissue. Granulations are nothing more than a young, soft, mucous tissue, analogous to marrow." [3]

The next case presents us with a good illustration of suppurative osteo-myelitis in one of the stump-bones. It was a double amputation, and in the other stump-bone both the carnified and the gangrenous conditions of the marrow were found.

CASE XXIX. *Primary Amputation of Both Arms for Extensive Lacerated Wounds inflicted by Machinery; Osteo-myelitis with Hepatization, Suppuration, and Gangrene of the Marrow; Death on the Twentieth*

[1] Vide *Lectures on Cellular Pathology*, p. 465. [2] *Op. cit.*, p. 465.
[3] *Op. cit.*, pp. 465, 466.

Day; Autopsy; Clinical History, reported by Dr. Edward Farrell, House Surgeon at Bellevue Hospital. — Tobias Dillon, aged 24 years, a native of Jamaica, and a very healthy man, was admitted to Bellevue Hospital in the service of Professor Hamilton, on the 21st of November, 1865. He had been injured about two hours before admission, by becoming entangled in some machinery, and got both arms very much lacerated from the hand to a short distance above the elbow-joint. Both arms were amputated in their middle about five hours after the accident. The left arm was amputated by the circular, and the right one by the double-flap method. He reacted well after the operation, but complained of having severe pain in the stumps, which was relieved by the hypodermic injection of morphia, and he rested well during the night. Union by the first intention was procured in the upper part of both stumps, and healthy suppuration commenced, on the third day after the operation, in the remaining parts of them. He did not complain of any pain whatever. He continued to do well for ten days after the operation. He always reported himself as feeling well, had a good appetite, and asked sometimes to be allowed to sit up. The suppuration from the flap operation was greater than from the circular. The end of the bone could be seen in the left stump (*i. e.*, the one made by the circular operation), and some brownish-looking granulations were observed to protrude from the medullary cavity.

Double amputation of arms.

On the eleventh day after the operation he had a severe chill, followed by profuse sweating. The chills continued at irregular intervals during the next two days, when he began to suffer from diarrhœa and vomiting. There was not any change in the condition of the stumps after the bad symptoms set in. The discharge continued healthy, and the patient did not complain of any increase of pain. He soon sank into a typhoid condition, became delirious, and died on the twentieth day after the operation, of pyæmia.

Chill on eleventh day.

Died on twentieth day.

Autopsy twelve hours after death. The soft parts of the stumps did not present an unhealthy appearance. A small abscess was found in the left lung, and the surface of its lower lobe was covered with recent lymph. The left pleural cavity contained a small quantity of sero-purulent fluid. A small abscess was found in the great lobe of the liver.

Pus in lungs, pleura, and liver.

Description of the Stump-bones belonging to this Case. — They were obtained Tuesday, December 12, at the autopsy, and were taken away from the hospital by the author with the permission of Professor Hamilton, for the purpose of making a critical examination of them.

The bone of the right stump measures seven and one half inches in length. It is denuded of periosteum for some distance above its sawn end, white in color where denuded,

Right arm, double-flap amputation.

and apparently necrosed; but no line of separation is yet discernible with the naked eye or with a hand-glass. The periosteum is redder than natural, and considerably thickened, about the lower part of the bone. On making a longitudinal section of the piece, and carefully scraping the bone-dust off from the sawn surfaces with the edge of a scalpel, the medullary tissue is seen to be generally inflamed; but the morbid appearance is not uniform, for in some parts of it the inflammatory process is of an older date, or farther advanced, or in a different stage from what it is in other parts.[1] The medullary tissue about the lower part of the canal has suppurated or been transformed into pus. For a distance of three fourths of an inch above the sawn end of the bone, the contents of the medullary canal, or such of them as have not flowed out, are very soft in consistence, and have a dirty yellowish-gray color. Examined with the microscope, this substance is found to consist of pus corpuscles, free oil-globules, and much granular matter.

Next above this suppurating section, the marrow is in a sloughing or mortified condition for a distance of half an inch. It has a very dark brown, almost black, color, and a distinctly marked gangrenous odor.[2] Examined with the microscope, it is found to consist of broken-down marrow cells, connective tissue, and granular matter all stained with decomposing hematoidin.

Above the black spot all the medullary tissue has a dark-red color and a tolerably firm consistence, instead of the pale-yellow hue and very soft consistence which normally belong to this tissue in that situation, and in the canals of the long bones generally, during the adult period of life. The discoloration of the medullary tissue is, however, somewhat deeper in the shaft than it is in the epiphysis (head) of the bone. Examined with the microscope, the carnified marrow belonging to the shaft is seen to consist of a multitude of granular free marrow cells, some parent cells, a few fat vesicles, and a great deal of free oil. A portion of red marrow taken from a cancellus in the head of the bone, and examined with the microscope, is found to consist of a great quantity of granular free marrow cells, with fat vesicles much fewer in number than in the normal condition.

The bone of the left stump measures seven inches in length, and a mass of reddish-brown-colored granulations protrudes nearly half an inch from the medullary canal at its

Left arm, circular amputation.

[1] Vide Plate VII.

[2] Vide Plate VII.

sawn end. It is denuded of periosteum, and therefore bare, for a distance of half an inch above this end. Where denuded, it is white in color, and necrosed, but no line of separation can be discerned. The periosteum is redder than natural, and much thickened about this portion of the bone. It also contains plates of newly formed reddish-colored osseous tissue developed in its substance and in the connective tissue lying immediately exterior to it. After splitting the bone lengthwise with a saw, and scraping off the bone dust carefully with the edge of a scalpel, from the surfaces of the section, the medullary tissue is found to exhibit strong evidences of inflammatory action. In some places it is carnified, having a reddish-brown, almost a chocolate color, and a flesh-like consistence. In other places it is the seat of purulent collections (abscesses). The increased consistence, as well as the dark color, is very striking. In the medullary canal, enveloped more or less completely by reddish-brown marrow, is an irregularly shaped abscess, having a length of three inches, and filled with dirty greenish, yellowish-gray colored, stinking pus.[1] This long, narrow abscess commences one inch above the sawn end of the bone, and extends upwards to within three fourths of an inch of its surgical neck. Above the abscess we see many small isolated grayish-white dots, located almost entirely in the cancelli. They are foci of suppuration. The medullary tissue in the midst of which these foci of suppuration are placed, and which also surrounds the abscess, has the reddish-brown color already mentioned.

On submitting the tough flesh-like chocolate-colored granulation tissue which protrudes from the sawn end of the bone, and fills the medullary canal thereabouts, to a microscopical examination, it is found to consist of granular marrow cells, connective tissue, spindle-shaped fibre cells, capillary vessels, and free oil, with extensive discoloration from hematoïdin.

Examined with the microscope, the matter from the principal abscess is found to consist of pus corpuscles, granular matter, the débris of pus corpuscles, and free oil.

Some substance taken from a cancellus at a point corresponding with the anatomical neck of the bone, and examined with the microscope, is seen to consist of granular matter, pus corpuscles, free marrow cells, and some parent marrow cells. The free marrow cells were granular; some of them were highly so.

Comments. — The facts stated in the last paragraph are of much

[1] Vide Plate VI.

importance in a pathological point of view. They tend to shed some considerable light upon the metamorphoses which the cell-formations of the marrow undergo when subjected to inflammatory irritation. In this specimen, when examined with the microscope, we had distinctly brought before us several of the leading points pertaining to the transformation of the medullary tissue into pus through the agency of the inflammatory process. We had first some parent marrow cells; next we had a quantity of free marrow cells, but they were granular; then we had pus corpuscles and amorphous matter. It seems to me that these facts afford strong support to Virchow's views concerning the way in which suppuration of the medullary tissue is produced, or, rather, of the histological transformations by which it is effected. His views have already been stated at considerable length. The microscopical examination of this case was made by Dr. J. W. S. Gouley, in concert with the author.

Transformation of marrow into pus.

3. *Of Gangrene of the Marrow.* — We have already seen that inflammatory irritation of a certain grade produces hepatization of the marrow, that another grade of this kind of irritation, especially if the irritation be prolonged, induces suppuration of the medullary tissue. Now, a still higher grade of inflammatory irritation may occasion gangrene of this tissue.

Gangrene of marrow.

When the marrow becomes mortified, it usually presents a very dark color, and emits a gangrenous odor. Sometimes its color is almost black. If subjected to a microscopical examination, it is seen that its cell formations are all destroyed, that it consists of amorphous matter the debris of the preëxisting histological structures, with perhaps some connective tissue, all stained of a dark color by decomposing hematoidin.

Robin, while speaking of the morbid states of the marrow, says, in some conditions, the inflammation becomes so intense that the medullary cells cease to receive materials fit for their continuous molecular renovation. The marrow then softens, and becomes liquid, and flows from the extremity of the fractured or amputated bone. When this liquid is examined, there are found in it only molecular granules in suspension, sometimes nucleated cells, and always drops of oil; for the liquefaction melts down the walls of the fat vesicles, and sets free the oil. This is always a grave fact, as has been demonstrated in the study of fractures, especially those of the long bones, and in certain other pathological conditions, such as amputations followed by so-

Drops of oil.

called purulent infection.[1] The author's own experience fully corroborates the views of Robin with regard to the gravity of this lesion of the marrow. Mention of this pathological condition is made here because it seems to be closely allied to gangrene.

In the case that was last related, the stump-bone belonging to the right arm exhibited the carnified, the suppurating, and the gangrenous forms of osteo-myelitis, all in close relation with each other.[1]

Gangrene of marrow not often met with.

Gangrene of the marrow appears to be a pathological condition that is not often met with even in military practice. This is probably due to the high degree of vascularity with which the medullary tissue is endowed. It is certain that suppuration of the marrow occurs very much more frequently than gangrene. Mr. B. Phillips, in a paper to which reference has already been several times made, says the state of gangrene does not often occur in the marrow; and this observation tallies exactly with my own experience.

The next three cases afford examples of gangrene of the marrow. A perusal of them will give a better idea of this pathological condition than many words expended in description. In two of them the mortification appears to have had an inflammatory, but in the third a spontaneous or mephitic origin. Two of them occurred in the author's practice at Stanton Hospital, and one in that of Professor Dubrueil at Montpellier.

Case XXX. *Acute Osteo-myelitis following Secondary Amputation for Gunshot Injury involving the Knee-joint; Death Thirteen Days after the Operation from Pyæmia; one Part of the Medullary Tissue in Stump-bone gangrenous; another Part "red inflamed" in Appearance; Thrombosis; Secondary Abscesses in Lungs.* — William S. Smith, private, Co. I, 5th North Carolina Infantry (Confederate), aged 24, was admitted into the Stanton U. S. Army General Hospital, May 13, 1864, with a gunshot wound of the left knee-joint, received May 9, in battle near the Wilderness, Va. The ball entered anteriorly near the inner side of the patella, and escaped posteriorly about three inches below the flexure or bend of the knee, having grooved the internal condyle of the femur in its course.

When admitted into the hospital, the knee-joint was already much swelled and inflamed. His constitutional state was also bad. He was pale (anæmic), feeble, and had irritative fever of a low type. Ordered the ice-dressing to be applied to the wounded joint, and nutrients, to-

[1] Vide *American Journal Medical Sciences*, October, 1865, p. 501.
[2] Vide Plate VII.

gether with tonics and stimulants, to be taken internally. The following tonic and stimulating mixture was prescribed: ℞. Tinct. ferri muriatis, f. ʒii. Spirit. frumenti, f. oj. M. Sumend. One ounce every three hours.

May 18. — The patient has not improved, but on the contrary is constantly getting worse. His knee-joint is greatly swelled and very painful. Inflammatory swelling is extending rapidly down the leg. He also has a good deal of irritative fever; skin hot and dry; pulse frequent and irritable; he is considerably prostrated and restless.

Anæsthesia having been produced with sulphuric ether, the thigh was amputated in its lower third by the double-flap method. Only about four ounces of blood were shed by the operation. A good deal of shock was, however, produced, and reaction came on but slowly. When the effects of the anæsthetic had passed away, the following mixture was prescribed for him, namely: ℞. Ferri et quiniæ citratis, ʒiss. Spirit. frumenti, f. oj. M. Sumend. One ounce every three hours. He was also directed to take opiates in sufficient quantity to keep him free from pain, and have his strength kept up by nutrients, such as essence of beef, eggs, etc. The knee-joint contained about six ounces of purulent fluid. The operation was performed, I think, by Dr. George A. Mursick, U. S. Vols.

Secondary amputation of thigh.

May 26. — There is no improvement; the stump shows no disposition to heal; he has anorexia with great debility, and we are compelled to administer alcoholic stimulants in any form that may suit his fancy; he is restless, and expresses a desire to die; mind clear; pulse averages 130; tongue dry; stomach irritable. The stump-bone protrudes, and the discharge is ill conditioned. Ordered the following lotion to be applied to his stump: ℞. Potass. permanganat. ʒss. Aquæ fontanæ, f. oij. M. D. During the next three days he continued to grow weaker gradually.

May 30. — He is now sinking rapidly; he has considerable dyspnœa, and his respirations are hurried; the discharge from the stump is very offensive in smell; he refuses to take either food or stimulants in any form.

May 31. — He continued to sink, and died to-day of pyæmia. He did not have any chills, and his skin did not assume an icterode hue, during any part of the course of the disease, in which respects his case differs materially from many others that have come under our observation.

Died of pyæmia.

Autopsy. — The lower end of the stump-bone was denuded of periosteum for about half an inch above its sawn extremity; and the periosteum, still higher up, was loosened, more or less, for the space of an inch, but not detached. There were no deposits of new osseous tissue on the exterior of the stump-bone, and no products of reparative action at the sawn end of it. The medullary tissue, in the stump-bone, had a dark reddish-brown-color, and a very offensive

Gangrene of the marrow.

(gangrenous) odor through a section about one half inch thick, situated at the lower end. Above this gangrenous part the marrow presented, centrally, a yellowish-gray color through a space one inch in length. At the circumference of this yellowish-gray portion of marrow, the medullary tissue, which lay in contact with the internal laminæ of the bone, had a dark-red color extending to the depth of one or two lines. Above this yellowish-gray portion, the marrow presented a reddish-yellow color in its interior; but its exterior, which came in contact with the osseous tube, had a bright-red color extending to the depth of two or three lines, and looked like fresh granulations; from this "red inflamed" tissue numerous minute vessels were seen shooting into the interior of the marrow, and forming networks therein. A section of the stump-bone, four inches long, was examined. The medullary tissue was exposed to view by splitting it lengthwise with a saw.

The profunda, the superficial femoral, and the external iliac veins leading from the stump, were all filled with recently coagulated blood (thrombus). When viewed externally after exposure by dissection, they presented a blue color, and, opposite their valves, a knotted appearance.

The inguinal glands, and the chain of lymphatic ganglia which accompanies the external iliac vein, were enlarged (inflamed). The divided extremity of the femoral artery was slate-colored and softened to the extent of one inch, and this part appeared to be about to slough off. The tube was, however, firmly occluded (obliterated) at the junction of the sloughing with the sound part of the vessel.

The exterior of the lungs contained about a dozen small superficial abscesses, and the interior numerous patches of lobular pneumonia. The abscesses were grayish-yellow in color, and surrounded by a dark-red areola of inflamed pulmonary tissue.

The liver was not enlarged, but buff-colored, fatty, and very soft. The spleen was not enlarged, but paler than usual in color and very soft. The cortical portion of the kidneys was red and injected. The pyramids were pale, but well defined.

Inflammatory gangrene of the marrow seldom occupies more than a circumscribed portion, and is always associated with carnification or hepatization of the neighboring medullary tissue. Non-inflammatory mortification of the marrow, on the contrary, is generally diffuse in character and unaccompanied by sclerosis.

Case XXXI. *Acute Osteo-myelitis of Tibia following Erysipelas of Leg; Amputation of Thigh; Autopsy of the Member; Medullary Tissue in some Places deep-red in Color, and in others black and Gangrenous; Necrosis;* related by M. Dubrueil, Professor at Montpellier. — A young man, aged 20, who had suffered from suppuration in the cervical and axillary lymphatic glands, was attacked in the left leg by erysipelas, ac-

companied with severe pain and inflammatory fever. Ulceration of the soft parts ensued, and exposed the whole inner side of the tibia. Diarrhœa came on, and, for the preservation of life, it became necessary to amputate the limb above the knee, on the forty-third day from the commencement of the disease. On examining the limb, all the soft parts were found infiltrated with bloody serum. The periosteum of the tibia, denser and more vascular than it naturally is, adhered but loosely to the bone, and plates of osseous matter were deposited in its tissue. There were several ulcerated channels extending through the walls of the bone to the medullary tube. Several portions of the bone between these channels had perished. The medullary tissue in some situations had a deep-red color, resembling the conjunction of the eye in chemosis, and in others it was *black, with a gangrenous odor.*[1]

Case XXXII. *Secondary Amputation of Thigh for commencing Gangrene of Leg following Gunshot Injury; Death from Exhaustion Two Days after the Operation; the Autopsy showed the Marrow in the Stump-bone to be gangrenous (mephitic).* — George F. Curtiss, Corporal, Co. C, 10th New Jersey Vols., aged 22, was admitted to the Stanton U. S. Army General Hospital, June 4, 1864, on account of a gunshot wound inflicted May 31st, in the action at Old Church, Va. He had sustained a compound comminuted fracture of the head of the right tibia, implicating the knee-joint. The bullet entered anteriorly about three inches below the patella, passed backwards and upwards, shattered the head of the tibia into many fragments, and then lodging, remained unextracted. The fracture extended to the knee-joint.

When he came to the hospital, four days after the wound was inflicted, the knee-joint was greatly distended by effusion; the whole limb was much swollen as high as the groin; the leg, besides being greatly swelled, was beginning to be gangrenous; the skin below the wound was dark-brown in color and mottled in appearance; there were also several large blebs, filled with brownish-colored serum, on the lower part of the leg; and no pulsation was perceived in the posterior tibial artery. He was also suffering from irritative fever in a marked form; his pulse was frequent and jerking, his skin hot and dry; he was very restless, and his countenance had a dusky hue. It was supposed that the gangrene of his leg had been occasioned by some injury of the posterior tibial or popliteal artery inflicted by the bullet. On the 5th of June, anæsthesia having been produced with sulphuric ether, the thigh was amputated in its upper third by the circular method. The operation was attended with a good deal of shock, from which he reacted very slowly. He did not long survive the operation, for he died two days afterwards (June 7) of exhaustion. Amputation of thigh.

On examining the amputated member, it was found that the soft tissues

[1] Vide Stanley on *Diseases of the Bones*, p. 54, Am. ed.

of the leg and thigh were soaked in a reddish-colored serum, which had produced the swelling of those parts, that the blood-vessels were not injured by the bullet, and the bullet itself (a minie) was found lodged in the bone.

The gangrene of the leg appeared to have been produced by acute inflammatory œdema (diffuse cellulitis).

Some hours after death the stump was examined, and the medullary tissue of the stump-bone was found to be in a gangrenous condition throughout. It was discolored (dark), and emitted the offensive odor of mortification. No carnification nor sclerosis was observed.

Mephitic gangrene of marrow.

This case probably affords an example of mephitic or spontaneous gangrene of the marrow, and as such is introduced in this place for the purpose of giving as complete a view as possible of the subject of gangrene of the marrow. It is not certain that the inflammatory process had much to do, if anything, in producing the gangrene of the medullary tissue here found.

In connection with the subject of the pathological anatomy of osteo-myelitis in general, we may remark further that the morbid process may be confined to the medullary tissue occupying only a portion of a bone, which is the rule; or it may involve all the medullary tissue contained in a bone, and such cases are not unfrequently seen; or, in exceptional instances, it may affect the medullary tissue of more than one bone at the same time.

More frequent in lower than upper extremities.

Furthermore, osteo-myelitis occurs much more frequently in the lower than in the upper extremity. Thus, in sixty-one cases of this disease which I have tabulated, it occurred in the lower extremities in fifty-one instances, in the upper extremities eight times, and in the cranium twice.

Professor Alonzo Clark has also informed the writer that he has met with *suppurative osteo-myelitis in the lower jaw* in two cases of *cancrum oris*, *noma*. Both of them occurred in the persons of delicate children, and terminated fatally. At the autopsy it was ascertained that the cancellous structure of the inferior maxilla was filled with purulent matter.

Terminations, Complications, and Consequences of Osteo-myelitis. —1. *Recovery.* The chronic forms of this disease, in a large majority of instances, terminate ultimately in cure, if proper surgical treatment be employed. The sub-acute forms not unfrequently

become aggravated by the influence of extraneous circumstances, which is especially liable to happen in the transportation of the wounded before their cure is sufficiently advanced. But the sub-acute variety may also terminate directly in recovery. When this result is about to take place, the inflammatory irritation subsides, the symptoms which indicate to the clinical observer the presence of the inflammatory process disappear, and then the diseased part is gradually restored to a healthy condition. The acute forms may subside into the sub-acute and chronic varieties, and in this way eventually end in recovery. A large proportion of the cases of chronic osteo-myelitis which the surgeon is called on to treat originate in this manner. But even acute osteo-myelitis may terminate directly in resolution of the disease, and the recovery of the patient.[1]

The following case, which occurred in the author's practice, furnishes an example of this fortunate result.

CASE XXXIII. *Severe Osteo-myelitis following Resection of a Thigh Stump, performed for Necrosis and to remedy the Bad Shape of the Stump itself; Recovery.* — Private J. S. Irens, Co. I., 61st N. Y. Vols., was admitted to the Stanton U. S. Army General Hospital, Dec. 26, 1862, on account of an amputation of his right thigh, in its middle third, which had been performed for gunshot injuries inflicted at the battle of Fredericksburg, Va., Dec. 13. It is believed that the operation was primary.

His convalescence was slow. The stump healed by granulation, and some protrusion of bone occurred. Necrosis of a part of the stump-bone also took place. It was subsequently ascertained that the necrosis was central. A large quantity of new osseous tissue was deposited about the sawn end of the stump-bone ; indeed, the quantity of the new osseous deposit was so large as to make the end of the bone decidedly bulbous in shape. The stump now refused to heal. The cicatricial tissue was firmly adherent to the bulbous expansion of the bone.

On the 17th of March, 1863, the operation of resecting the stump was performed by the author. It was opened by a free incision down to the bone, the closely adherent soft parts were carefully detached from the new bony growth with the ends of the fingers and with the handle of a scalpel, and then enough of the bone

Resection of bone.

[1] Pirogoff assents to the doctrine that osteo-myelitis may terminate in subsidence or resolution. He says, "In cases where a marked fungous excrescence protruding from the medullary canal in stumps after amputation, renders the previous existence or presence of osteo-myelitis very probable, and which terminate in recovery, a subs dence of the disease may be assumed to have taken place." We may here remark that such a protrusion of hepatized marrow from the free end of stump-bones not unfrequently occurs in patients who get well; at least, such has been our experience.

was excised with a saw to correct the shape of the stump, and to liberate the necrosed portion which was already separated from the living bone. It was then found that the necrosis was of the variety called central. The operation did not require the application of any ligatures. Sulphuric ether was employed as an anæsthetic.

This operation was followed by severe osteo-myelitis; the patient endured much suffering, and his life was in great peril for many days. But he ultimately made a good recovery with a satisfactory stump, and was discharged from the service July 7th, 1863. At one time during the progress of the disease, he became very much reduced in flesh and strength; but he had recovered both again before he left the hospital.

The osteo-myelitis in his case was accompanied by the following symptoms: Firstly, severe pain in the stump-bone, of a heavy, aching character. This pain was more severe at night. The stump itself was swelled, and tense, and hot, but the color of its integument was unaltered. The pus discharged from it was scanty in quantity, and thin and serous in quality, while the inflammation of the medullary tissue lasted. He also had at the same time a good deal of constitutional disturbance; an anxious countenance, a hot, dry skin, a frequent, quick, irritable pulse, and loss of appetite. He was also very restless, and deprived of sleep by the pain. He emaciated rapidly, and became pale and weak, but did not sink completely down into a typhoid condition.

The treatment consisted mainly in the application of the ice-dressing to the stump, in the administration of saline drinks together with anodynes, given p. r. n. to alleviate his pain.

July 18, 1865, I met this patient, unexpectedly, on a North River steamboat. He appeared to be in good health, and stated that his stump had continued sound and free from pain ever since he left the hospital, over two years previously.

Complete recovery without necrosis.

Comments. — In this case the original amputation had been followed by an inflammation of the medullary tissue of such a character as to produce central necrosis, and to render resection of the stump-bone necessary in order to get a good result and a useful stump. It was the second operation, or the resection of the stump-bone, that was followed by the symptoms of intense inflammation of the medullary tissue described above. Nevertheless the inflammatory process subsided without the production of a fresh necrosis or the occurrence of any accident whatever.

2. *Central necrosis*, by which is meant, in case the shaft of any long bone is the part involved, necrosis of its *internal laminæ*, or those osseous laminæ which lie next to the marrow, and, in case the epiphysis of any long bone is the part in-

Central necrosis.

volved, necrosis of some portion of the spongy structure which lies within the wall formed by the external compact tissue. Osteo-myelitis, more especially the chronic variety of this disease, is often attended with central necrosis. Such a result happened in Case V. In the case last related, also, the first operation, the amputation was followed by central necrosis of the stump-bone. The Army Medical Museum at Washington contains a great number and variety of specimens illustrating this form of osseous gangrene. Central necrosis occurs most frequently in the stumps of amputated limbs; but it is also met with sometimes in connection with fracture, and occasionally it occurs spontaneously, *i. e.* it is not connected with any traumatic lesion.

When inflammation of the marrow, whether traumatic or spontaneous, induces central necrosis, it does it by causing the contiguous osseous laminæ to be deprived of nutrient blood. Thus, dry gangrene occurs in the part of the bone where the circulation is arrested. Necrosis is only another name for dry gangrene of bone. Wet or *mephitic gangrene* of the osseous tissue differs widely from it.[1]

Dry and wet gangrene of bone.

Now osteo-myelitis probably induces central necrosis in two distinct ways: 1st, by destroying or occluding the nutrient arteries which pass through the diseased marrow to the bone, and, 2d, by producing acute inflammation of the osseous laminæ which afterwards become necrosed. In such cases the inflammatory process in an intense form spreads from the marrow to the bone. The unyielding nature of the osseous tissue forbids inflammatory swelling to occur. The capillaries of the Haversian canals become compressed and strangulated, or occluded by the products of the inflammatory process, because the bony walls which surround them do not give way. Thus the circulation of the blood in them is speedily arrested and death of the parts which they supply, immediately follows.[2] It is also probable that osteo-myelitis induces central necrosis much more frequently by the last than by the first of the ways above-mentioned. Still, the first named, when it coöperates with the last, probably assists considerably in the destructive work. It appears, however, to be doubtful whether it ever produces necrosis, at least of considerable amount, unless it is aided by secondary ostitis. In these two ways, then, it is safe to assume that inflammation of the marrow induces central necrosis.

The following case presents us with a good example of this variety of osseous gangrene occurring in the arm.

[1] See Chapter on Necrosis.

[2] See Chapter on Necrosis.

CASE XXXIV. *Extensive Central Necrosis of Left Humerus following Injury of the Bone, inflicted by a Gunshot Projectile; Extraction of the Sequestrum; Recovery;* contributed by James E. Steel, M. D., late Acting Assistant Surgeon, U. S. Army. — Corp. James F. Strong, Co. F, 56th Penn. Vols., aged about 25, and originally of vigorous constitution, was admitted to the De Camp U. S. Army General Hospital, at David's Island, January 9th, 1863, on account of a gunshot wound of the left arm, associated with injury of the bone, which had been inflicted more than four months previously, August 29th, 1862. He had been under treatment for several months at the Bellevue Hospital, from which institution he was transferred to David's Island on the 9th of January, 1863. The purulent discharge from the wound was profuse at the time; the patient was also pale in color, thin in flesh, and a good deal weakened in respect to strength. On exploring the wound with a probe, it was found that it penetrated a bony case (involucrum) through a cloaca, and that there was a fragment of necrosed bone, having considerable size, lying on the inside, and apparently completely separated from the living tissues which surrounded it. He was placed upon a supporting plan of treatment.

Fig. 4.

Dr. Steel's Case of Central Necrosis following Osteo-myelitis.

March 27, 1863. — His general condition having become more favorable, the necrosed bone was extracted by operation. The involucrum was exposed by a longitudinal incision through the soft parts, and a mortise was then made in the bony case, by applying the crown of a trephine three times, and cutting off the projecting angles with Liston's osteotome. Next the sequestrum was divided with the osteotome, which permitted it to be seized with forceps, and extracted

without difficulty. The upper portion was extracted first. The operation was performed about seven months after the original injury was inflicted. On putting the two parts of the sequestrum together, it was found to be over six inches in length. It was narrow, and its external surface presented an eroded and worm-eaten appearance. The exterior of the sequestrum was also very convex, and its inferior extremity, which came from the external condyle of the humerus, was considerably curved.[1] The involucrum was long and thick. The patient improved very rapidly after the operation, and was well at the end of six or eight weeks. He afterwards entered the Veteran Reserve Corps, 1st Battalion, at David's Island.

Fig. 5.

Necrosis in Totality following Osteo-myelitis. (Humeral Stump.)

Necrosis in totality.

3. Osteo-myelitis sometimes leads to the occurrence of *necrosis in totality*, by which is meant the death of a bone in its whole thickness or almost its whole thickness. In bad cases of inflammation of the marrow, occurring in the long bones, the inflammatory process spreads from it to the contiguous parts, for example, to the osseous tissue, to the periosteum, and sometimes to the parts external to that membrane. Now, the compact tissue of the shafts of the long bones is supplied with nutrient blood, mainly, but not entirely, by arteries which reach it through the medium of the marrow and the periosteum. When, as a sequel

[1] Vide Fig. 4. Short fragment, lower end, exterior represented.

of the inflammatory process, all the blood which is derived from the medullary vessels is suddenly shut off, together with a good part of that derived from the periosteal arteries, the vitality of the osseous tissue is likely to be destroyed, from the centre almost through to the periosteum. When the whole of the periosteal supply of blood is abruptly stopped along with that derived from the medullary tissue, the necrosis is likely to embrace the entire thickness of the bone. But if any capacity whatever to supply blood to the circumferential laminæ remains in the periosteum, then the particles of bone thus nourished will adhere to the periosteum when it separates itself from the dead bone, and will come away along with it.[1]

We are, however, compelled in many cases of *necrosis in totality* to seek for some proximate cause of the osseous gangrene besides inflammatory destruction of the marrow, and detachment of the periosteum, because we not unfrequently find, on investigating the clinical history of such cases, that the periosteum did not become detached from the bone till after the necrosis had occurred. The periosteal abscess did not produce the osseous gangrene, but followed it. The periosteum did not separate from the bone until the latter died.

Again, the destruction of periosteum, whether traumatic or spontaneous, is not attended with necrosis of the underlying bone unless some lesion of that structure itself is also present. Furthermore, the marrow may be extensively or almost entirely destroyed by the inflammatory process in the great canal of the long bones without inducing necrosis. Several cases belonging to both of these categories are related in this section. Observation has also shown that when the periosteum on the one hand, or the medullary tissue on the other, has been extensively destroyed, the lost part is not unfrequently reproduced through the agency of the living bone. It is also probable that the periosteum and the marrow may sometimes both be simultaneously destroyed to considerable extent without compromising the vitality of the osseous tissue exposed thereby. In the cases of osteo-myelitis belonging to the category now under consideration, we must look upon the consecutive inflammation of the bone tissue itself as probably the most powerful of all the proximate causes of the osseous gangrene. It

[1] Figure 5 gives a good representation of necrosis in totality as it occurs in stumps. In by far the greater part of the specimen the circumferential laminæ are wanting because they adhered to the periosteum and were detached with that membrane. In one place, however, the circumferential laminæ also were necrosed, as is well shown in the cut. The longitudinal grooves are plainly discernible on this part.

arrests the circulation of the blood in the diseased part of the bone in the way just pointed out in connection with the subject of central necrosis.[1] This form of dry gangrene of bone is mainly inflammatory in its origin. The ostitis which directly occasions it, is called secondary or consecutive, because it is induced by a pre-existing inflammation of the marrow. In such cases the morbid process which spreads from the marrow to the bone and the periosteum, is generally very acute in character.

Secondary ostitis.

The next case affords a striking example of necrosis in totality, or nearly so, which was probably induced by osteo-myelitis.

Case XXXV. *Gunshot Wound involving Right Tibia; Osteo-myelitis; Necrosis of almost all of the Shaft; Extraction of Sequestrum by Operation; Recovery with a Useful Limb.* — Private Wm. H. Marston, Co. B, 17th Mich. Vol., aged 23, and of good constitution, was wounded in front of Petersburg, Va., June 18th, 1864, in his right leg. A rifle-ball (supposed by the patient to be an explosive one) struck the tibia anteriorly, just below its tubercle, *drilling* the bone in its passage, then emerged posteriorly, just below the head of the fibula, and behind that bone. The tibia was not fractured, but, as stated above, was *drilled completely through*, the hole being large enough to readily admit the index finger. The patient states that he was taken to the field hospital of the 1st Division, 9th Army Corps. Several splinters and pieces of broken bone were extracted by operation. He remained there two days. Then he was transferred to Washington, and entered the Finley U. S. A. General Hospital. About two or three weeks after admission to that hospital, the leg suddenly became very painful, and was attacked with sloughing (supposed at the time to be hospital gangrene). Finally, extensive necrosis of the bone occurred, with a good deal of denudation. In August he was transferred to Newark, N. J., and entered the Ward U. S. A. General Hospital there on the 18th of that month.

At that time a large ulcer extended from the tubercle of the tibia to within a few inches of the ankle-joint, having in one place a width of three inches. The tibia was uncovered to the extent of four inches, and its surface was seen to be dark-colored, and eroded or worm-eaten in appearance. The discharge was profuse, and the patient's strength was much reduced.

He was placed upon appropriate supporting treatment, and improved in consequence of it.

On the 1st of October, the sequestrum being loose and the patient's condition good, it was deemed advisable to extract it by operation, which was accordingly done by Dr. James B. Cutter, Acting Assistant Sur-

[1] See also the Chapter on Necrosis.

geon, U. S. A. The sequestrum was very large, embracing most of the shaft of the tibia, and on that account gave some trouble in its removal.

Necrosis of most of shaft of tibia.

The patient did well after the operation, although his convalescence was slow. New osseous tissue was developed from the periosteum, a new bone was formed, and ultimately the patient recovered with a useful leg.

This account of the case has been compiled by the author from the patient's own statements, and from Dr. Cutter's report. The patient is a young man of much more than ordinary intelligence, and thoroughly reliable in what he says.

The sequestrum measures exactly eight inches in length, and embraces almost the whole thickness of the tibia. Its exterior presents an uneven, eroded, or worm-eaten appearance from adherence of particles of the circumferential laminæ to the periosteum at the time that membrane separated itself from the bone. The bone had perished in its whole thickness except these particles from its exterior which remained adherent to the periosteum. All the osseous tissue supplied with blood from the marrow had perished, and nearly all of that supplied from the periosteum had died also.

It is obvious that in this case the necrosis was not produced by causes which operated on the bone from its exterior, because, under such circumstances, the circumferential laminæ would have been the first to die, whereas particles of these laminæ were all that retained vitality and escaped destruction. It is, however, probable for reasons already stated while speaking of central and total necrosis, that the inflammatory process spread from the marrow to the bone and produced a very acute and extensive ostitis.

4. Osteo-myelitis not unfrequently leads to *osteo-porosis*, and sometimes to *caries*. In the cases belonging to this category, the inflammatory process spreads from the marrow to the contiguous bone, and induces a *degenerative ostitis* there, which, after a time, results in *osteo-porosis* (interstitial medullization), or, when the degenerative process is more acute or becomes further advanced, occasions a carious condition of the bone.[1] Generally, ostitis, properly so called, is a secondary disorder. So far as we now know, the inflammatory process does not affect the

Osteo-porosis and caries.

[1] See Prof. Gouley's case, No. V., and that of Sergt. Waltz, No. VI., together with the comments on them. See also Cases VIII. and XXII., and the chapters on Ostitis and Caries in this section.

bone cells proper, except secondarily. In the cases where osseous inflammation (so called) occurs, the first effects of the inflammatory process are seen in the elementary structures of the marrow, especially its cells, in the contents of the Haversian canal, and in the histological elements of the periosteum, especially those belonging to its deep or proliferating layer. Primary ostitis is a disorder of extremely rare occurrence. As a secondary affection, inflammation of the bone-tissue is not unfrequently met with. It follows both medullitis and periostitis, but the former much oftener than the latter. When secondary ostitis induces *osteo-porosis*, *i. e.*, rarefaction or interstitial medullization of bone, it does so by causing the medullary spaces and vascular canals to become progressively enlarged. In such cases the calcified bone-tissue gradually melts away and disappears from transformation into new medullary tissue. The osseous structure is not absolutely destroyed and replaced by an entirely new growth, but it is metamorphosed by the inflammatory process into new medullary tissue. In this way the marrow grows at the expense of the bone. In this way it sometimes happens, when this process occurs in the femur or tibia, that the compact tissue of the shaft becomes thinned to a mere shell of bone filled with new, red, sclerosed, or carnified medullary tissue, and when this process occurs in an epiphysis, the cancelli of which it is composed may become so much enlarged by thinning and disappearance of the osseous septa that the epiphysis itself can readily be incised with a scalpel; and in extreme cases the cancelli are found to coalesce so much that the external laminæ of such epiphysis appears to merely inclose a cavity filled with a new medullary growth. This form of ostitis is called degenerative, because it leads to the disappearance of bony tissue. It is essentially chronic in character; and, according to the author's experience, it is met with most frequently in the condyles of the femur so far as the epiphyses are concerned, and in the bodies of the vertebræ so far as spongy bones in general are concerned.

Osseous structure changed into medullary tissue.

5. *Pyarthrosis.* — It happens not unfrequently[1] that when the medullary tissue of a long bone is inflamed, the morbid process extends upwards through the epiphysis, and, invading the joint, produces suppurative inflammation therein. In this way pyarthrosis of the ankle is produced when the tarsal bones are involved with osteo-myelitis, pyarthrosis of the knee when the

Suppuration in joints.

[1] Of fifty-one cases of osteo-myelitis, related in this chapter, *pyarthrosis* occurred in five instances.

medullary tissue of the tibia is inflamed, and suppuration of the hip-joint when the marrow of the femur is invaded by this disease.

Osteo-myelitis prone to travel upwards.

Indeed, osteo-myelitis almost always shows a very strong tendency to travel upwards towards the trunk, which is shown, not only by penetrating the joints as already mentioned, but also in cases of fractured bones, the disease progresses much more rapidly in the proximal than in the distal fragment.[1]

When the inflammatory process spreads beyond the suppurating marrow into a neighboring articulation, sometimes the entrance of that process into the joint is accompanied by perforation of the cartilage of incrustation with minute holes which look as if they might have been made with a punch. This perforated appearance was very strongly marked in the cartilage incrusting the head of the femur in Case X. The hip-joint contained a quantity of purulent matter. The cancelli situated directly underneath the perforations of the cartilage were filled with pus, which was shown by microscopical examination of their contents. Now, these little holes in the cartilage were obviously made by a process of ulceration, and it is not improbable that such ulceration was excited by the suppuration of the underlying cancelli, and that some purulent matter, in this way, escaped from them into the joint, enough, perhaps, to kindle a suppurative inflammation there.

Pyarthrosis, when occasioned by an extension of the osteo-myelitic process, generally comes on without producing any violent symptoms. It is usually not painful, and, at the same time, advances but slowly. It is not a complication which belongs to the earlier periods of osteo-myelitis. Chassaignac states that he has

Pyarthrosis between fifteenth and nineteenth days.

never known it to supervene before the twelfth day, and that he has seen it occur only between the fifteenth and the nineteenth days. The same writer considers it quite characteristic of this form of pyarthrosis that it makes its appearance silently.[2]

Our case, No. VI., that of Sergeant Waltz, furnishes another example of pyarthrosis of the hip, occasioned by osteo-myelitis.

Again, when the inflammatory process spreads from the medullary tissue into a joint, and produces suppuration there, it does not confine itself to the new limit, but is inclined to go beyond it, and invade the next bone in the direction of the trunk. This is precisely what happened in Case No. X., that of Suffern; for it was found at the autopsy that there was pyarthrosis of the hip resulting

[1] Vide Plates I. and II.

[2] *Traité Pratique de la Suppuration*, t. i. p. 475.

from osteo-myelitis of the femur, but there was also suppurative inflammation of the medullary tissue in the os innominatum, and the cartilage of incrustation that lined the cotyloid cavity was perforated by a number of small holes similar to those discovered on the head of the femur. The disease seems to have spread from the hip-joint to the pelvic bones.

The next case is taken from the author's practice and furnishes an illustration of the same peculiarity with regard to the spread of osteo-myelitis from the tibia to the knee-joint, and then to the femur.

Case XXXVI. *Primary Amputation of Left Leg at Upper Third for Gunshot Fracture of both Bones at Lower Third, followed by Suppurative Osteo-myelitis (acute), Pyarthrosis of Knee, and Death from Pyæmia, Thirty-seven Days after the Operation.* — Private Christian Bundy, Co. F, 6th Wisconsin Vols., aged 30, was admitted to the Stanton U. S. Army General Hospital, May 18th, 1864, for a recent amputation of the left leg at the junction of its upper and middle thirds by the circular method. He informed us that he was wounded in the battle of Spottsylvania C. H., May 10th, by a minie ball which shattered both the tibia and fibula in the lower third of the leg, that the operation was performed the next day (May 11th) on the field, and that his health was good at the time.

When the patient was admitted into the hospital, he was somewhat debilitated, but otherwise appeared to be doing well; the stump was swelled, but, on the whole, looked good, and the discharge was healthy. Prescribed the ice-dressing for the stump, a nutritious diet, and spiritus frumenti f. ʒvi. daily. During the next twelve days the treatment remained unchanged.

June 1. — He had a chill and other symptoms of pyæmia. Ordered quiniæ sulph. grs. x. to be taken in the morning before breakfast, and quiniæ sulph. grs. v. to be taken every four hours through the day and night; the nutrients and alcoholic stimulant to be continued.

June 3. — He had another chill; directed the same treatment to be continued.

June 7. — He had two chills; stump doing *not* well; it was swelled, painful, and had ceased to granulate, but the discharge from it continued to be of fair quality. Directed ferri et potass. tart. grs. v., q. q. h. sumend. to be added to the other medication, and a weak solution of the permanganate of potassa to be applied to the stump as a wash.

June 12. — The chills continue; patient delirious; has a bronzed complexion, involuntary evacuations of bowels, with great and rapidly increasing debility; stump sloughing. Directed the quinine to be continued in same doses as usual, but the spiritus frumenti to be increased to f. ʒi. every two hours, and the ferri et potass. tart. to grs. x. every four hours.

June 16. — He is failing fast.

June 17. — He died of pyæmia.

Autopsy twelve hours after death. On opening the stump, and removing the bones, and dividing them lengthwise, it was found that the medullary tissue of both the tibia and fibula was intensely inflamed and suppurating. The knee-joint also was inflamed, and filled with a dark-colored fetid pus. The cartilages of the knee-joint had a dark color, and were in a morbid condition. An abscess filled with dark-colored stinking pus, and communicating with the joint, extended six inches above the joint among the muscles of the thigh. There was also osteo-myelitis in the lower part of the femur. The inflammation of the medullary tissue extended about six inches up the shaft of that bone.

The femoral vein was obstructed or filled up by a recent thrombus (thrombosis). The viscera appeared to be normal.

The abscess of the thigh had been occasioned by the spontaneous perforation or rupture of the subcrureal pouch of the knee-joint, and the extravasation of purulent matter from the joint into the deep connective tissue which resulted therefrom.

6. *Osteo-myelitis may occur simultaneously in more than one Bone.* — In the case just related, the disease commenced in the bones of the leg, and, spreading from them to the knee-joint, invaded the femur. In the case of Suffern (No. X.) the disease commenced in the femur, and, spreading from it to the hip-joint, invaded the os innominatum. In the following case, reported by Stanley, however, inflammation of the medullary tissue appears to have commenced in the tibia and femur about the same time. Chassaignac also has reported a case in which multiple osteo-myelitis occurred.

Simultaneously in more than one bone.

Non-suppurative Inflammation (acute) in the Medullary Tissue of both the Femur and Tibia of same Limb, without Apparent Cause; Result fatal. — A lad, fourteen years old, was, without apparent cause, suddenly attacked by pain deep in the thigh, and at the same time by pain, more severe, deep in the leg. The whole limb quickly became enormously swelled, from hip to ankle. Extensive suppuration ensued in the soft parts around the tibia. Free incisions were made for the evacuation of the matter; but the boy became hectic, and sank rapidly. On examining the limb, Mr. Stanley found a large quantity of matter around the tibia, and that its periosteum had, in great part, been destroyed. In those situations where portions of the periosteum remained, new osseous tissue was deposited on the bone. Around these osseous deposits the surface of the bone was extensively ulcerated, and some of its outer lamellæ had perished. Within its medullary tube, lymph had been deposited. In the thigh similar changes had taken place, but in a less active form.

No matter had been produced around the femur; its periosteum was entire, but there were osseous deposits on its exterior, and lymph was found within its medullary tube.

The history of this case indicated, that inflammation occurred simultaneously in the medullary tissue of both the femur and the tibia, that the inflammation was most severe within the tibia, and that, consequently, the most destructive effects ensued on the surface of that bone, and in the soft parts around it.[1] Both femur and tibia.

7. *New Bony Growths and New Osseous Tissue.* — We have already seen that inflammation of the medullary tissue is not unfrequently accompanied by the development of new bony growths in the medullary canals of the long bones, called technically *endostoses*, and that the new bone is produced by direct transformation of the medullary into osseous tissue.[2] But it often happens that the inflammatory irritation is propagated to the periosteum at the same time, and occasions the development of new osseous tissue, in the form of laminæ, between that membrane and the bone, known as *periostosis*. If we examine the bone at this time, we discover an increase in its thickness to greater or less extent, which, however, terminates insensibly at some distance from the point where it commenced, the distance, of course, varying with the case. In a vast majority of the instances in which amputation is performed, this thickening of the bone, in the nature of periostosis, occurs; but to discover it, we must get an opportunity to examine the stump soon after cicatrization has been completed; for, after a few months, the superabundant matter is oftentimes absorbed, that is, removed by a retrograde metamorphosis of its histological elements, and the bone becomes restored to its natural state. (Phillips.) The *periosteum, stimulated by the inflammatory irritation* which has been propagated to it from the marrow, *swells up*, i. e. *thickens*, and becomes *reddened in color*. At the same time great activity is excited among the histological elements belonging to the deepest and most vascular layer of this membrane. The periosteal cells multiply themselves (proliferate) with great rapidity. "The greater the irritation, the greater also the proliferation, and the more considerable the swelling of the Endostosis and periostosis.

[1] Vide Stanley on *Diseases of the Bones*, p. 55, Am. ed., 1849.

[2] It is by this process that the medullary canal becomes sealed up at the end of stump-bones after successful amputations; and probably inflammation of the marrow, when moderate in degree, whatever its origin may be, whether spontaneous or traumatic, very frequently terminates in the formation of new bone (endostosis). If, however, the medullitis is intense in degree, it does not end in the formation of new osseous tissue in the medullary canal, but speedily induces suppuration (abscess) of the marrow, as already stated.

growing spot. The cells which thus result from the proliferation of the periosteal corpuscles are converted into bone-corpuscles exactly in the way I described when speaking of the marrow."[1] The same writer also says, —

"In the neighborhood of the surface of the bone, the intercellular substance grows dense, and becomes almost cartilaginous, the cells throw out processes, become stellate, and at last the calcification of the intercellular substance ensues. If the irritation is very great, the corpuscles grow very considerably, and then real cartilage is produced; the corpuscles enlarge to such an extent that they grow into large oval or round cells, and each of these forms a capsule around itself by secretion. In this manner, cartilage may arise in the periosteum also, by means of a direct transformation of its proliferating layers; but it is by no means necessary that real, true, cartilage should be produced; generally only the osteoid transformation takes place, when the intercellular substance becomes sclerotic, and at once calcifies."

Periostoses seldom formed through cartilage cells.

Periostoses are, for the most part, developed from a direct transformation of the new cells and intercellular substance which is produced by the internal layer of the inflamed periosteum into new osseous tissue. Occasionally, however, they are produced through the transformation of intermediary cartilage into bone. The author has not in any case seen an exudation of lymph beneath the periosteum out of which new bone was formed.

But inflammatory irritation, having its starting-point in the marrow, occasions not only *endostosis* and *periostosis*. It sometimes also extends beyond the periosteum into the intermuscular connective tissue, and excites the development or production of new bone in that tissue, external to the periosteum. These new bony growths are sometimes called *osteophytes*. Case XXVII. presented us with an example of a remarkable osteophyte which was produced in this way.

Osteophytes.

The next case also presents us with an excellent example of new bone developed in the connective tissue on the outside of the periosteum, as one of the consequences of osteo-myelitis. It was observed in the author's practice.

Case XXXVII. *Primary Amputation of Right Thigh for Gunshot Fracture; Death on the Twenty-first Day, with Pyæmic Symptoms; Suppurative Osteo-myelitis discovered at the Autopsy; Veins normal; no Visceral Abscesses.* — John L. Clark, Sergt. 5th S. C. Cavalry (Confeder-

[1] Virchow, *op. cit.* p. 469.

ate), aged 27, admitted into the Stanton U. S. Army General Hospital, June 12, 1864; was wounded in battle near Salem Church, Va., May 28, by a minie ball, which fractured the lower end of the right femur. The thigh was amputated in field hospital May 29th, by antero-posterior skin-flaps. Patient said that he was in good condition at the time of the operation. At the time of admission to hospital, the stump looked well, but his bowels were constipated, and his tongue coated. The treatment consisted in the administration of saline cathartics, stimulants, and tonics (syrup ferri et potass. tart.), and the application of ice-dressings to the stump. He did very well until June 15, on which day he had a severe pyæmic chill. Quiniæ sulph., in large doses, was added to the treatment. June 16, the chill was repeated; the edges of the flap assumed a dark color, and the discharge from the stump became thin and reddish. The chills increased each day in frequency and severity; the complexion assumed a bronzed hue; he sank into a muttering delirium, and died, apparently of pyæmia, June 18.

Autopsy. — The bone of the stump exhibited purulent osteo-myelitis. An ash-colored slough of the marrow extended up the medullary canal for half an inch above the sawn end of the bone. Above this slough, for about an inch and a half, the medullary tissue presented a reddish-yellow color, its vascularity being increased (hyperæmia), and a portion of its fat having been absorbed. The next two inches of the marrow had a greenish-yellow color, and *contained five small abscesses.* The cancellous structure of the stump-bone also presented a greenish-yellow appearance, and the greater portion of its fat appeared to have been absorbed. There was no deposit of new osseous tissue in the medullary canal (endostosis). The lower end of the stump-bone was denuded of its periosteum to the extent of half an inch, that is, it was bare as far up as the ash-colored slough of the marrow extended. Above this point the periosteum was very much thickened, and reddened in color. There was also an extensive deposit of new bone between it and the old stump-bone (periostosis). *The muscular tissue external to the periosteum in this locality, contained a deposit of new bony material (osteophytes) spread through it to a distance of about two inches from the periosteum. This new osseous tissue was situated in the muscular structure itself, and had not grown outwards from the periosteum pushing the muscular tissue before it as its size increased.*

Osteophytes in muscular tissue.

The lungs were normal. The liver was softened. The spleen was enlarged and soft. The kidneys were soft. *The veins were normal.*

Comments. — In this case the new osseous formation found at the autopsy in the muscular tissue of the stump, was obviously not developed from the periosteum. It was produced, in all probability, by the direct transformation of the histological elements of the inflamed connective tissue, or, in other words, by a transformation of

the newly formed connective tissue cells into bone-corpuscles, and of the intercellular substance into calcified osteine, in a manner strictly analagous to that by which medullary tissue is converted into bone, and that by which new osseous tissue is developed from the periosteum. The new osseous tissue in this case, although it was situated in the midst of muscular structures, was not developed from the muscular fibres, but from the connective tissue which constitutes the intermuscular planes, and therefore the muscular fibres were readily detected running through the midst of it. This new bony substance was formed by a direct sclerosis of the connective tissue, which was effected essentially by a progressive hardening of the intercellular substance terminating in its calcification. The formation of new osseous from connective tissue is often witnessed where the stimulus to such development is furnished by causes other than inflammation of the medullary tissue. It is often met with in connection with fractures, especially those of the thigh, where it acts no inconsiderable part in the formation of *callus*.

Osteophytes not developed from muscular tissue.

We have thus seen the important office which the medullary tissue, the periosteum, and the connective tissue may discharge in the production of new bone (*osteogenesis*). We have also seen how inflammatory irritation, having its starting-point in the marrow, may produce *endostosis*, *exostosis*, and *osteophytes*. We have further seen that these forms of pathological ossification have all been called into existence by an active process, by an irritation, which is closely connected with the inflammatory process in all its relations.

We may add that in no case examined by us has the development of new bone appeared to proceed from blood-clot, or exudation of lymph, or extravasation of any nutritive material, but from direct transformation of preëxisting structures. In the cases where new bone was developed from the connective tissue, some lesion of the neighboring osseous structure was always present. In a very large number of gunshot wounds which have passed under our observation, we have seen no instance in which the connective tissue was engaged in the production of new osseous tissue, unless the neighboring bone was also injured.

From pre-existing structures.

8. *Acute Periosteal Abscess.* — Suppurative inflammation of the medullary tissue is sometimes accompanied with acute suppurative periostitis and the formation of an abscess between the periosteum and the bone. In such cases the inflammatory process propagated from the marrow to the osteogenetic

Sub-periosteal abscess — acute.

layer of the periosteum, is so intense in character as to produce, not new osseous tissue, but purulent matter, whereby this membrane becomes separated and raised up from the bone. The formation of an acute periosteal abscess, in consequence of osteo-myelitis, is generally attended with high fever and great constitutional disturbance, and usually denotes that inflammatory necrosis has also extensively occurred. According to the author's experience, this kind of abscess is not of frequent occurrence. It is met with in but a small proportion of the cases of traumatic osteo-myelitis ; more frequently, however, in connection with the spontaneous variety of this disease, judging from Chassaignac's statements.

Sub-periosteal suppuration of a chronic character not unfrequently occurs as a result of osteo-myelitis. In the head it produces the condition of the scalp which is well known as the "puffy tumor" of Pott. Wherever it occurs in connection with osteo-myelitis, it generally denotes that a corresponding portion of bone is dead ; and this obtains in other parts of the body besides the head. Chronic.

With regard to *spontaneous separation* or *detachment* of the periosteum from the bone as a consequence of osteo-myelitis, we should state in general that, according to our experience, it never occurs, or is but slight in extent, unless the underlying bone is at the same time necrosed. Limited detachment of this membrane, however, is often met with at the end of stump-bones in amputated limbs and at the seat of compound fractures, during the stage of suppuration, when necrosis is not present, but it does not seem to have any necessary connection with osteo-myelitis. In such cases the periosteum is generally much thickened and reddened at the place of detachment; and the detachment itself appears to be due mainly to mechanical injury and consecutive inflammation of this membrane.

With regard to *loosening* of the periosteum as a consequence of osteo-myelitis, upon which much stress has been laid by some writers, we should also state that, according to our experience, a moderate degree of such loosening pretty frequently occurs. In such cases this membrane is always considerably tumefied and reddened. We have, however, but seldom met with instances where the loosening was so great that the periosteum became stripped from the bone by muscular contraction, and there- Loosening of periosteum.

fore believe that the occurrence of loosening in this form is rather exceptional. It is also certain that suppurative osteo-myelitis often runs its course to a fatal termination with but little or no disturbance of the periosteum of any description.

Abscess of the soft parts.

9. *Abscesses in the soft structures external to the periosteum are* often indirectly occasioned by osteo-myelitis. In the chronic forms of this disease such collections of purulent matter are affairs of frequent occurrence, mainly on account of the irritation produced by necrosed bone and its exfoliation. Indeed, in the progress of chronic osteo-myelitis, we sometimes witness a number of such purulent collections formed in quite a regular succession.

But inflammation of the medullary tissue may also occasion abscess of the soft parts by perforating the compact wall of the bone, and discharging purulent matter through the hole thus made, into the inter-muscular connective tissue when the bone is deep-seated, or into the subcutaneous connective tissue when superficial. This is precisely what happened in Professor Gouley's case (No. V.), in Chassaignac's case (No. VII.), in Pott's case (No. VIII.), in Hey's case (No. XXI.), and in another case related by the same writer, which we have elsewhere referred to.[1] In the cases belonging to this category, the swelling generally occurs suddenly, and has usually been preceded, for some time, by more or less pain in the bone, accompanied perhaps with fever, both of which subside on the appearance of the tumefaction.

In the next case, taken from Stanley, an account is given of a circumscribed abscess of the arm, which was produced in the way mentioned above. Other instances of the same sort, besides those just mentioned, are related or referred to in this work; and there is reason to believe that this complication or consequence of suppurative inflammation (abscess) of the marrow is of comparatively frequent occurrence. Indeed, most surgeons who have seen much practice, will probably recollect cases of this nature in which abscesses suddenly and unaccountably appeared in the extremities, when their attention is called to the subject.

CASE XXXVIII. *Suppurative Inflammation (chronic) of the Medullary Tissue in the Shaft of the Humerus; Spontaneous Perforation of the Shaft, and Consecutive Abscess in the Soft Parts; an Ulcerated Channel through the Inferior Epiphysis permits the Escape of Matter from the*

[1] See p. 271 of this chapter.

Medullary Tube into the Elbow-joint; Destructive Arthritis; Amputation. — A man was admitted to St. Bartholomew's Hospital for a swelling of the arm, who stated that for several months he had been troubled with *pain in the bone of his arm*, which had, however, recently subsided on the appearance of the swelling. On examining him, Mr. Stanley found an abscess, in the upper third and inside of the arm, having the size of an English walnut. Its cyst was so loose and circumscribed that it appeared to be wholly subcutaneous. Accordingly, it was not supposed to have any connection with the bone, and the real nature of the disease was not suspected. But, after some time, destructive inflammation suddenly supervened in the elbow-joint, for which the arm was amputated near the shoulder. On examining the humerus, Mr. Stanley found its medullary tube filled with purulent fluid and lymph, and the medullary membrane much thickened. Minute ulcerated holes through the parietes of the bone communicated with the abscess in the adjacent soft parts, and in the articular end there was an ulcerated channel through which the matter had escaped from the medullary tube into the elbow-joint.[1] No cause is assigned for the osteo-myelitis, and the result of the amputation is not stated.

10. *Thrombosis* frequently[2] occurs as a complication of osteo-myelitis. Oftentimes this disease seems to impress upon the blood in the living vessels, especially the veins of the affected part, a remarkable tendency to coagulate, or to form large-sized clots in them, while the patient is yet alive. These coagula are called *thrombi*, and the process which at first occasions them, and subsequently transforms them into a dirty-gray semi-fluid substance resembling pus, but which, on microscopical examination, is found to be not pus, is called *thrombosis*. Thrombosis.

In Cases III., XV., XXIV., XXVI., XXX., XXXVI., etc., the veins which returned the blood from the part affected with osteo-myelitis, were found, on making the autopsy, to be extensively obstructed, some of them were completely filled, with coagulated blood. Not unfrequently this blocked-up condition of the veins occasions a kind of bleeding which is called parenchymatous hemorrhage, and which is often very difficult to suppress.[3] Causes parenchymatous hemorrhage.

[1] Vide Stanley *On Diseases of the Bones*, p. 52. Am. ed., 1849.

[2] Of fifty-one cases of osteo-myelitis related in this chapter, seven are known to have had thrombosis. Other instances also are mentioned in other parts of this work. See chapter on Parenchymatous Hemorrhage in Section First, etc.

Pirogoff also has noticed the fact that osteo-myelitis is frequently accompanied by thrombosis, and that the small veins in the vicinity of the medullary abscess, as well as the more remote ones of the soft structures, are then found occluded with ichorous thrombi.

[3] Vide Case III., etc.: also the chapter on "Parenchymatous Hemorrhage," in Section First.

The following case is an example of suppurative osteo-myelitis, complicated with parenchymatous hemorrhage, and thrombosis of the popliteal and femoral veins. The thrombus was diagnosticated during life.

CASE XXXIX. *Primary Amputation of Right Leg at Upper Third; Suppurative Osteo-myelitis (acute); Pyarthrosis of the Knee; Death on the Fourteenth Day after the Operation, with Symptoms of Pyæmia; Thrombosis; had Parenchymatous Hemorrhage.* — Private James Hill, Co. A, 32d Mass. Vols., aged 49, was admitted to the Stanton U. S. Army General Hospital from the field, May 18, 1864. His right leg had been amputated about four inches below the knee-joint by the antero-posterior flap method. He stated that the operation was performed on the 12th for gunshot fracture of both bones of the leg with much destruction of the soft parts, inflicted in the battle of the Wilderness on the 11th. He also stated that he was in good health at the time of operation.

May 20. — He had retention of urine. The stump was swelled and painful. It also had sloughed badly up to where the bones were sawed off.

May 22. — Thigh also now swelled and painful; skin hot, pulse frequent and feeble, tongue dry and brown; he is much debilitated; has also diarrhœa and rigors.

May 23. — Parenchymatous hemorrhage occurred from the stump, and he lost about six ounces of blood before it was arrested. He is still more debilitated. He sweats profusely, and has rigors occurring at irregular periods. His skin is assuming a sallow hue. The superficial veins of the swollen thigh are enlarged, blue-colored, and unusually distinct, from which it is inferred, in connection with the other features of the case, that the popliteal and femoral veins are obstructed by thrombus. He died on the 26th, apparently from pyæmia.

Examination of the limb after death confirmed the diagnosis. There was thrombosis of the popliteal and femoral veins. The medullary tissue of the principal stump-bone (tibia) was inflamed and suppurating. The cancelli of the spongy structure at the upper end or head of the tibia contained some dirty-looking, ill-conditioned pus. The knee-joint contained about four ounces of fetid pus. The internal organs or viscera were not examined.

11. *Pyæmia* frequently occurs as a consequence of suppurative inflammation of the medullary tissue, and many instances thereof have already been given in these pages.[1] By the term pyæmia is here meant that form of the purulent infection

Pyæmia. Its meaning.

[1] Of the fifty-one cases of osteo-myelitis related in this chapter, pyæmia supervened in eighteen, all of which died. In nearly all of these cases, the suppurating marrow appears to have been the focus from which the purulent infection sprung. Furthermore, in cases

which is attended with the following symptoms: chills with profuse sweats occurring at irregular intervals, rapidly increasing debility, vomiting, diarrhœa, a yellowish, bronzed, or icterode hue of the skin, delirium, and a peculiarly mawkish odor of the breath and sweat.

Its relation to injuries of bone.

Allusion has already been made to the close relationship which exists between suppurative osteo-myelitis and pyæmia. No such relationship obtains between suppurative inflammation of any other tissue of the whole body and that disease. It is but seldom, speaking comparatively, that we meet with pyæmia in a severe form, unless it has followed a traumatic lesion of the osseous tissue, or a surgical operation rendered necessary by such lesion. The author cannot now recollect that he has seen in military practice more than three or four undoubted cases of pyæmia entirely unconnected with injury of bone. It is certain that the purulent infection follows traumatic lesions of bone much more frequently than traumatic lesions of all the other structures of the body put together.

Veins in the bone. Objections to theory.

Now this question immediately presents itself: Why is it that pyæmia is very apt to follow suppurative inflammation involving the medullary tissue of the femur, for example, and almost never occurs in connection with suppurative inflammation among the muscles of the thigh, unless a lesion of the osseous tissue is also present? In reply to this question, it has been suggested that a patulous condition of the veins in the osseous tissue which is injured, may occasion the difference. It is believed by some that a patulous condition of these veins may facilitate the absorption of the liquor puris, when the part of the bone that is injured is bathed in pus, and thus may promote the contamination of the system at large with a purulent infection. But to this theory two important objections present themselves: 1st, the patulous condition of the venous mouths on the injured osseous surface is, to say the least, not proven; and, 2d, in many cases of suppurative osteo-myelitis where pyæmia occurs, the bared osseous tissue is not bathed in pus. We may also state that, in very many instances where naked bone is, for a long time, bathed in purulent matter, pyæmia does not supervene.

of osteo-myelitis having a fatal termination, pyæmia is the immediate cause of death more frequently than all other causes combined. Thus, of fifty-one cases, thirty proved fatal; and of these, eighteen, or considerably more than one half, died of pyæmia. Hence it is believed that pyæmia is *par excellence* the form of systemic intoxication or disorder which osteo-myelitis induces. Clinical observation has also abundantly shown that purulent infection occurs but seldom in surgical practice, comparatively speaking, unless bone is injured or diseased.

Dr. Woodward's observations. Gangrene of marrow.

Again, Dr. Woodward says, "So far as my personal observation has gone, the pyæmic phenomena have been invariably[1] connected with the primary occurrence of local septic processes."[2] He also informs us that he means by "*septic processes* [occurring] *in connection with the local lesion*," those which are "*gangrenous or phagedenic*" in character.[3] He gives a graphic description of diffuse spontaneous (*i. e.* not inflammatory) gangrene of the marrow. He then says: —

"But in the cases which prove fatal by inducing pyæmia, no line of demarcation, no barrier of inflammation, limits the gangrenous portion, and the veins leading from the affected bone are usually full of coagula, which have entered into a form of putrefaction quite similar to that going on in the marrow. The ultimate result of this change is a yellowish or greenish-yellow fetid fluid, in which the microscope recognizes nothing but actively moving molecules, with bright centres and dark borders. I have once or twice seen the veins leading from the flaps of a sloughing stump in a similar condition; but *in most of the cases* to which my attention was drawn, *the veins affected, proceeded directly from the diseased bone itself. The putrefactive change going on in the marrow is transmitted through the coagulated blood mass in the veins by actual continuity.*"[4]

Now, according to Dr. Woodward's explanation of the origin of pyæmia, the reason why lesions of the marrow are more likely to be followed by pyæmia than lesions of the parts external to the bone, is because the marrow is more prone to be affected with diffuse gangrene than the parts external to the bone. In our judgment, these observations of Dr. Woodward possess great interest and value, when considered with some limitations which have been suggested to us by clinical experience. Chief among these limitations are the following: 1. This explanation of the origin of pyæmia is not applicable in most cases of this disorder that result from lesions of the medullary tissue, because, in a large majority of such instances, no gangrene nor phagedena of the marrow is present. For example, of *eighteen* cases of

Objections to the theory.

[1] In justice to Dr. Woodward, the following should also be stated: "I do not mean to lay this down as an unchangeable law," he says. "My observations have not been as yet sufficiently numerous to make me positive of more than that this is at least an important and frequent group of cases" (p. 196).

[2] See *Report on the Causes and Pathology of Pyæmia*, by J. J. Woodward, M. D., etc., in *Transactions of the American Medical Association* for 1869, pp. 196, 197, 198.

[3] Page 198.

[4] Page 197. (The italics have been introduced.)

pyæmia produced by osteo-myelitis and resulting fatally, which are related in this chapter, in *twelve*, or exactly two thirds, there was no gangrenous, nor phagedenic, nor sloughing condition of the diseased medullary tissue. Moreover, in the *six* cases where mortification or sloughing of the marrow was found at the autopsy, it is rendered probable by the clinical history that in at least several of them the sphacelus did not occur until after the pyæmic invasion, and, instead of being the cause, it was the consequence of such invasion. 2. Gangrene of the marrow, on the other hand, may be found at the autopsy when the clinical history shows conclusively that the subject did not have pyæmia. The author published such a case in the "American Journal of the Medical Sciences," for April, 1865.[1] Case No. XXXII. of this chapter, that of George F. Curtiss, belongs to the same category. It was an instance of diffuse mephitic or spontaneous gangrene of the marrow; but in neither of them were the symptoms manifested which belong to pyæmia. In both of them septæmia, in the ordinary sense of the term, occurred; that is, such septæmia as we meet with in cases of consecutive gangrene, of senile gangrene, of spreading inflammatory gangrene or diffuse gangrenous cellulitis, and of hospital gangrene, — cases in which no one could be likely to ascribe the great depression of the vital powers and the other constitutional phenomena to pyæmia. In Case No. XLII. of this chapter, that of Ephraim E. Sterling, there was also extensive gangrene of the marrow, and death without the occurrence of pyæmia. From these clinical facts we infer that Dr. Woodward's explanation of the origin of pyæmia is not the true one. Nevertheless, the observations on this subject which Dr. Woodward has recorded, possess great value, 1st, because they show the way in which the blood in general circulation becomes contaminated by what is ordinarily called the septicæmic process, together with some of the most important of the steps of that process; and, 2d, because they prove that absorption of putrefactive matter occurs much more readily from the marrow than from the soft structures external to the bone.

The author's theory.

We are now for the first time prepared to offer a rational explanation of the fact that pyæmia is produced by abscess of the marrow much more frequently than by abscess of the muscular or connective tissue. While we deny that pyæmia is a disorder synonymous with septæmia in the full or philosophical sense of the term, for reasons which have just been stated, we

[1] Pages 300, 301.

have no doubt that it is a variety of septæmia, or that the pyæmic poison is septic in its nature and origin.[1] The term septæmia, properly speaking, embraces several varieties of blood-poisoning which are clinically distinct from pyæmia; for example, those which result from gangrene produced by wounds of blood-vessels,[2] from senile gangrene, from spreading inflammatory gangrene, from hospital gangrene, and from dissection wounds. The term pyæmia represents a species of the genus septæmia; and as the putrefactive matters which induce septæmia are absorbed from the marrow more readily than from other structures, so the septic poison which induces pyæmia is absorbed more readily from abscess of the marrow than from abscess of other tissues. That the absorbing power of the marrow is much greater than that of many other structures, is shown by some of Ollier's experiments; for example, the injection of ten drops of a concentrated solution of cyanide of potassium into the marrow has produced death in rabbits in from ten to twenty seconds, the rapidity being proportionate to the proximity of the place of injection to the trunk. The same amount of this liquid injected into the liver, the lung, or the peritoneal cavity, did not produce fatal results.[3] We say, then, that pyæmia is induced by abscess of the marrow much more frequently than by abscess of other parts, because the pyæmic poison is absorbed from the marrow much more readily than from other structures. It is also probable that the matter of marrow abscesses is more liable to undergo the septic transformation which induces pyæmia, than the matter contained in other abscesses. We found this opinion upon a statement made by Virchow, corroborated by others, and attested by ourselves, that there is no tissue in the body which is more disposed to undergo purulent transformation than the marrow.

Pyæmia a species of septæmia.

The next two cases are examples of suppurative osteo-myelitis which proved fatal by inducing pyæmia. An interesting feature which belongs to both of them, is that secondary or visceral abscesses did not occur. Both of them were met with in the author's practice.

CASE XL. *Suppurative Osteo-myelitis following Secondary Amputation of the Thigh for Gunshot Fracture of both Bones of the Leg; Death from Pyæmia Fifteen Days after the Operation; Internal Organs healthy.* — George W. Tillapaugh, Corporal, Co. B, 151st New York Vols., aged

[1] See chapter on Pyæmia.

[2] See chapter on Consecutive Gangrene in Section First.

[3] See *Traité Experimental et Clinique de la Régeneration des Os*, etc., par M. Ollier, Paris, 1867, Chapter Second; also *American Journal Medical Sciences*, January, 1868, p. 148.

23, was admitted into the Stanton U. S. Army General Hospital, June 4, 1864, on account of gunshot injuries of the right leg, received near Mechanicsville, Va., May 31. On examining him, the leg was found to be much swelled, its muscular tissue extensively infiltrated with pus, and both bones fractured and very much comminuted. He was somewhat debilitated, but, upon the whole, his constitutional state might be considered as "fair."

June 6. — Sulphuric ether having been administered as anæsthetic, his thigh was amputated at the junction of its middle and lower thirds, by the circular method. He bore the operation well.

With a view to support his strength, he was directed to have strong nutrients, tonics, such as quinine and iron, and alcoholic stimulants.

June 14. — He had diarrhœa, with vomiting.

June 16. — He took pyæmic chills.

June 21. — He died of pyæmia.

Autopsy. — On splitting the stump-bone lengthwise with a saw, its medullary tissue was found to be inflamed, thickened, and condensed. It also contained about half a dozen small, isolated abscesses.

The internal organs (viscera) were healthy.

Case XLI. *Suppurative Osteo-myelitis (acute) following Secondary Amputation of Left Thigh, for Gunshot Fracture of Femur; Death produced by Pyæmia Six Days after the Operation; no Visceral Abscesses.* — Ernest Lochterhand, Private, Co. H, 37th Wisconsin Vols., aged 34, was admitted into the Stanton U. S. Army General Hospital, July 1, 1864, for gunshot fracture of the left femur, in middle third. He stated that he had been wounded in battle, near Petersburg, Va., June 17. On examining him, it was found that a musket-ball had penetrated the thigh on the outer side, and after fracturing the bone, with much comminution, lodged. The wound was then (July 1) suppurating freely. The limb was much swelled and inflamed. There was also synovitis of the knee-joint. The bone was much comminuted, the fragments displaced, and a number of them were also detached. A large abscess had formed about the seat of fracture. He had some irritative fever, and complained a good deal of pain in the knee-joint; tongue clean, and appetite moderate; general condition, upon the whole, fair. On the 3d day of July, the limb was amputated, by the circular method, at the junction of the upper and middle thirds of the thigh; anæsthetic sulphuric ether. The bullet, which was conical in shape, was found lying in the abscess at the place of fracture, having been split into two pieces by the osseous tissue. The force of the projectile, it is obvious, was mostly spent before striking the bone. He was put upon the use of nutrients, tonics, and alcoholic stimulants. Opium, in full doses, was also administered.

July 5. — He got a heavy chill, and complained a good deal of pa[illegible]

the stump; prescribed quiniæ sulph. grs. x. ter in die; other remedial measures to be continued unchanged; he required opiates in full doses.

On the 6th, 7th, and 8th, he had chills at irregular intervals, with fever and sweats; his skin assumed a yellowish hue; the lymphatic glands of his groin became swelled and painful. The stump-pain also continued. There was no effort on the part of the reparative process to heal the stump. The discharge from it was thin and serous till the end.

He failed fast. On the night of the 8th he had convulsive movements.

He died July 9, of pyæmia.

Autopsy. — The medullary tissue of the stump-bone was found to be inflamed and suppurating. Each lung contained obsolete tubercles at its apex, but presented no other abnormity. The liver was much enlarged and fatty. The other viscera were normal. No secondary abscesses were found.

Comments. — The swollen and painful condition of the lymphatic glands of the groin in this case denotes that the glandular system was becoming implicated in the morbid process, and that a *leucocytotic* condition was about to supervene. This peculiar morbid state is a matter of considerable importance, especially in connection with pyæmia, since it is one of the pathological conditions which not unfrequently renders considerable assistance in making up the *tout-ensemble* of that disease.

Definition of leucocytosis.

By the term *leucocytosis*, from which the word leucocytotic is derived, is meant a morbid condition of the blood, accompanied by an increased proportion of the colorless corpuscles, which appears to depend upon an affection of the lymphatic glands. It is a state of anæmia, wherein the white globules are in great excess, and appears to be produced by excitation of the lymphatic glandular system.[1]

Leukæmia.

12. *Leukæmia* sometimes complicates the progress of osteomyelitis. This term has been introduced by Virchow to represent a morbid condition of the blood in which there is a positive diminution in the number of red corpuscles, and a positive increase in the number of colorless ones, depending apparently upon organic disease of the *spleen*. He states that, —

"Whilst in ordinary blood we can seldom count more than one colorless corpuscle to about three hundred colored ones, there are cases of leukæmia in which the increase of the colorless ones reaches such a height, that to every three red corpuscles there is one colorless one, or even two, or in which, indeed, the greater numbers are in favor of the colorless corpuscles."

[1] Vide Virchow's *Lectures on Cellular Pathology*, p. 201, etc.

"Now, upon investigating whence this curious change in the blood takes its origin, we find, in the great majority of cases, that it is a certain, definite organ which presents itself over and over again with convincing constancy as the one essentially diseased, — an organ which frequently, even at the outset of the malady, forms the chief object of the complaints and distress of the patients, namely, the *spleen*." Disease of spleen.

"In the histories of all the known cases of leukæmia, we only find it once as yet recorded, that the patient, after he had been for some time the subject of medical treatment, left the hospital considerably improved in health. In all the other cases the result was death." [1]

This disease is obviously one of great importance, and challenges the attention of all who are interested in the progress of medical science.

The following case presents an excellent example of leukæmia occurring as a complication of osteo-myelitis.

Case XLII. *Primary Amputation of Right Thigh for Gunshot Fracture of both Bones of Leg; Leukæmia; Anasarca; Death from what was supposed to be Pyæmic Pneumonia Ninety-five Days after the Wound was inflicted; Gangrenous Marrow; no Thrombosis; Spleen hypertrophied and indurated; Diagnosis of Pyæmia erroneous.* — Corporal Ephraim E. Sterling, Co. E, 143d Penn. Vols., aged 32, was admitted to the Stanton U. S. Army General Hospital, May 13, 1864, for a recent amputation of the right thigh at the lower third. He said that he received a gunshot wound of the leg in the upper third with comminuted fracture of both the tibia and fibula, May 9, in the battle of the Wilderness, and that the thigh was amputated the next day, on the field. He also said that he was in good condition at the time of the operation, excepting that the wound was very painful.

On examining him, it was found that the limb had been amputated by the flap method at the lower third of the thigh, as stated above. The particulars of the operation were unknown.

May 14. — He has some diarrhœa.

May 16. — Is better and doing well; the cold-water dressing to be applied to the stump.

May 27. — He had secondary hemorrhage from the stump to the extent of about six ounces; opened the stump, and applied a ligature to a small vessel which was bleeding.

June 30. — He was doing well. But subsequent to this date the patient gradually became pale and anæmic; his countenance assumed a dirty, waxy hue; his appetite and strength failed; the stump and the whole of the unmutilated lower extremity, together with the scrotum,

[1] Vide Virchow, op. cit., pp. 201 to 205.

became œdematous; dropsical effusions collected in the cavities of the abdomen, pleuræ, and pericardium; a large abscess formed in the muscular tissue of the stump, which, on being opened and its contents evacuated, did not close, and the dropsical effusion into the areolar tissue of the stump flowed freely from it as long as he lived. He also had pain in the stump.

August 10. — He complained of pain in his right side, had some cough with difficult breathing, and expectorated viscid sputa. Mucous rales and bronchial respiration were heard posteriorly over the lower lobe of the right lung. He did not improve, but gradually sank, and died August 12, of what was then supposed to be secondary or pyæmic pneumonia.

Autopsy eighteen hours after death. Areolar tissue of lower extremities œdematous; no rigor mortis; skin had a pale clay color. *Thorax:* each pleural cavity contained about a pint of pale limpid serum; the lower lobe of right lung was in the second stage of pneumonia (hepatized red); left lung œdematous, but otherwise healthy; the bag of the pericardium contained about four ounces of pale straw-colored serum; the muscular tissue of the heart was a pale fawn color, flabby and softened, but presented no other abnormity. *Abdomen:* its cavity contained about a quart of pale straw-colored serum; the liver was enlarged, pale-buff in color (fatty), and softened in texture; the gall-bladder contained about two ounces of bile of a light-brown color; the spleen was enlarged, harder than natural (indurated), of a light brick color, and, upon section, its trabeculæ were unusually prominent; the kidneys were pale and exsanguinated, but otherwise presented no abnormal appearance to the eye. *Stump:* from sloughing of the flaps the stump-bone had protruded about an inch; this portion was necrosed, and about to separate; on cutting the stump open, it was found that a deposit of new bone from the periosteum extended upwards a distance of about three inches, that it formed a tube (involucrum), and was not attached to the underlying osseous tissue (old); that the stump-bone was completely denuded to the same height (three inches), and necrosed to the same extent; on sawing the stump-bone open lengthwise, the marrow was found to be gangrenous all the way up to the same height above the end of the soft tissues constituting the stump (three inches); it exhibited a dark yellowish-green color, interspersed here and there with a small patch of yellow marrow, whose transformation had not been completed when the mortification occurred; it also had a gangrenous odor; in all about four inches of the stump-bone were necrosed, consisting of two sections; the first section embraced the portion that protruded, and was about one inch long; the second section embraced the portion that did not protrude, and was about three inches long; the first section was about to separate from the second; the marrow was gangrenous as high up as the necrosis extended. The veins did not contain any thrombi.

His urine at no time contained albumen. It was tested frequently to ascertain this fact, on account of the dropsical symptoms, but always with the same result, namely, no albumen was found.

No other tissue of the body was gangrenous besides the portion of the marrow above mentioned.

Comments. — The clinical history of this case, together with the autopsy, showed conclusively that this patient did not die of pyæmia nor pyæmic pneumonia.

The anasarca appears to have been produced by the peculiar condition of his blood, which was deficient in the red corpuscles, and contained the colorless corpuscles in excess.

On making the autopsy, the spleen was found to be hypertrophied, indurated, and possessed of an unnatural color. It was obviously the subject of organic disease, and this circumstance tends to support the views which Virchow has enunciated concerning the origin of leukæmia.

Spleen hypertrophied, etc.

13. Like other inflammatory disorders of a severe character, osteo-myelitis often proves fatal by inducing extreme *exhaustion*.

The next two cases are instances wherein this disease had such an unfortunate termination. Both of them occurred in the author's practice at Stanton Hospital. We may here remark that of thirty fatal cases of osteo-myelitis, six, that is, twenty per cent., died in this way.

Death from exhaustion.

Case XLIII. *Secondary Amputation of Left Thigh for Gunshot Wound of Left Knee-joint; Death by Exhaustion on the Fourth Day after the Operation; Red Inflamed Marrow revealed at the Autopsy.* — Private Joseph B. Hutchings, Co. G, 6th N. Y. Heavy Artillery, admitted to the Stanton U. S. Army General Hospital, June 4, 1864, from the field, stated that he was 22 years old, and that he had been wounded by a minie ball at Old Church, Va., May 30. On examination, it was found that a conical musket-ball had penetrated the front of the left knee-joint, and, passing upwards and backwards, had broken the internal condyle of the femur into many fragments. It finally escaped behind five or six inches above the articulation. The knee was much swelled, tender, and painful. The thigh also was much swelled and hot up to the groin. The leg likewise was swelled. A dark-colored pus flowed out from the wound. On the next day, June 5, the thigh was amputated by the circular method, high up in the upper third. The parts were œdematous at the place of operation (inflammatory œdema). The anæsthetic employed was sulphuric ether. The operation was attended with the loss of a considerable quantity of blood. The hemorrhage was parenchym

atous, and issued from the swollen and inflamed tissues of the thigh. At the time of operation his general condition was not favorable. He had severe irritative fever; countenance flushed, skin hot, pulse frequent and irritable; and he complained of feeling weak. The shock attending the operation was very great, and reaction was established with very much difficulty, and required for its accomplishment the administration of whiskey ad. lib., and of tinct. capsici, the prolonged use of the vapor of ammonia, the application of sinapisms to the epigastrium, wrists, etc., and bottles of warm water to the armpits, sides, etc. The stump was left open.

June 7. — His condition is feeble; the skin-flaps are sloughing; prognosis very bad.

June 8. — The sloughing of the skin-flap continues to extend, and he is obviously failing in spite of all that we can do for him.

He died on the night of June 9 and 10, at 12 o'clock, of exhaustion. He had obstinate vomiting on the last day of his life.

Autopsy. — The stump-bone was denuded of periosteum about its lower or sawn extremity. On dividing the stump-bone longitudinally with a saw, and cleaning the bone-dust off from the surfaces of the section, the marrow was found to be much more vascular than natural throughout the bone. It had a *bright-red* color, instead of the yellow hue which is normal in the femur during the adult period of life. Its consistence also was decidedly increased above the natural standard, and it could not be washed away with a smart stream of water. The marrow was carnified.

Comments. — In this case other causes besides inflammation of the marrow assisted in producing the fatal termination by exhaustion, and prominent among them was the shock of operation. The sloughing of the flaps appeared to be due to diminished vitality, and no doubt aided in exhausting the patient by inducing septæmia, at least to some extent.

"Shock" under ether.

CASE XLIV. *Chronic Osteo-myelitis following Gunshot Fracture of Femur; Death from Exhaustion almost Six Months after the Injury was inflicted.* — John Pool, Private, Co. H, 119th Penn. Vols., aged 23, hair and complexion light, was admitted into the Stanton U. S. Army General Hospital, Nov. 9th, 1863, from the front, on account of a gunshot fracture of the left thigh in its middle third, inflicted in battle at Rappahannock Station, two days previously (Nov. 7). The bullet penetrated the upper and outer part of the thigh. In the popliteal space there were two holes in the integument, both of which appeared to be orifices of exit. It seemed that the bullet struck the femur, fractured it with comminution, and was itself split, by contact with the bone, into at least two pieces, both of which afterwards escaped through separate openings in the skin.

A moderate synovitis of the knee-joint occurred. The treatment adopted was as follows: The wounded limb was propped up by long sand-bags, one placed on either side of it; extension was effected through the agency of a weight attached to the leg by means of two long strips of adhesive plaster, with which it was connected by a piece of rope of sufficient length to allow its suspension beyond the foot of the bed. The ice-dressing was applied to the knee and to the wounded thigh.

Jan. 24, 1864.— He is slowly failing; has profuse night sweats; is emaciating, and growing pale and weak; his pulse ranges from 110 to 120. The thigh is a good deal swelled. It contains abscesses situated both above and below the place of fracture, and a sort of badly elaborated pus issues from the orifice of entrance and one of the orifices of exit. A considerable degree of consolidation of the fracture has occurred by means of provisional callus. The synovial effusion has disappeared. On exploring the wound with the probe devised by Nelaton for the purpose of ascertaining whether a portion of the bullet did not remain unextracted, a number of detached fragments of bone were found lying loose at the place of fracture. It was resolved to extract them without delay. The patient being etherized, and placed upon his right side in bed, an incision about four inches long was made in the back part of his thigh, down to the femur, at the place of fracture, and six detached fragments of bone, each of which had a considerable size, were taken out. The largest piece was about two inches in length, by three-fourths of an inch in breadth. No lead was found.

He reacted promptly after the operation. The thigh was emphysematous, and the patient's general condition feeble and precarious for the next two days. Subsequently, however, he improved rapidly.

Feb. 15. — Pulse 80, and general condition fine. A few days afterwards he began to decline again.

February 24. — Enlarged the wound of operation, and extricated two more fragments of detached bone. After this he appeared to be better for a time, but the improvement was not permanent.

April 18. — He is now emaciated, pale, and feeble; pulse frequent and weak; tongue red and inclined to be dry; appetite capricious; and he is subject to attacks of diarrhœa. The whole limb is now greatly swelled all the way up to the hip; a slough has formed on the instep; there is a profuse discharge of thin, flaky pus from the wound of operation in back part of thigh; the knee-joint is distended with effusion, and the patella floats some distance above the condyles of the femur; he is steadily failing, and there is now no hope of saving his life without amputation. Accordingly he was placed under the full influence of sulphuric ether, an assistant compressed the femoral artery against the os pubis, and the operation of amputation was performed by the author, in the upper third of the thigh, by the double-flap method. The femur was sawn across about one and one half inches below the trochanter

minor. The soft parts of the thigh were so much diseased as not to admit the performance of the operation at any point below.

But little blood was lost by the operation. There was, however, a good deal of shock, but he reacted promptly afterwards. He was put upon the use of nutrients, alcoholic stimulants (spiritus vini Gallici) p. r. n., and opiates. He had had a good deal of pain in the thigh for a long time before the amputation.

In a short time the stump became sloughy; he gradually failed in strength, and died of exhaustion (*i. e.*, worn out) April 26, six months, less eleven days, after the wound was inflicted.

Examination of Amputated Member. — Extensive burrowing of pus among the muscles of thigh; numerous small pieces and scales of the bullet were found sticking in the muscles about seat of fracture; the ends of the broken femur are not in apposition, but separated from each other by the space which had formerly been occupied by the fragments of bone extracted by operation. Pretty firm union had, however, taken place by means of a bridge of new bone which arched over the chasm in front. On splitting the femur open with a saw, the marrow generally was found to present a coppery-red color, along with copious deposits of new reddish-colored osseous tissue in it (endostosis) for a considerable distance above the fracture. In the marrow below the fracture there was a large-sized chocolate-colored spot, which had obviously been produced by an old extravasation of blood. The substance of the marrow was decidedly firmer and tougher than normal, throughout the specimen. The extravasation of blood just mentioned was not in the form of a large clot, but it appeared to consist of an infiltration of the medullary tissue with blood (ecchymosis inflammatory). This extravasation of blood was probably *apoplectic* in character, and occasioned by an intense hyperæmia. There was a considerable deposit of new osseous tissue lying between the periosteum and the bone. The periosteum itself was thicker and redder than natural in that locality (inflamed), and from it these laminæ of new osseous tissue had been developed.

Bone from connective tissue.

The bridge of new bone, by which the two fragments of the broken femur were connected together, had been formed by the connective tissue. This fact affords a useful commentary upon the method which nature not unfrequently employs to unite fractures and to repair other damages sustained by bone.

Comments. — In this case new osseous tissue was produced by direct transformation of the inflamed marrow, by excitation of the osteogenetic layer of the periosteum, and by coincident excitation of the connective tissue. Thus we have presented to us three distinct methods by which pathological osteogenesis is effected. Thus,

Repairs of fractured bone.

again, we have shown to us the three principal ways in which the repair of a fractured bone takes place. There

is no mysterious organization of a previously exuded juice, no development of blastema or exudation corpuscles, no transformation of blood-clots or of supposititious lymph. There is no new process brought into action; nothing but a traumatic excitation of the ordinary bone-producing functions of the marrow, the periosteum, the bone itself, and the connective tisue. (Ollier.)

Concerning the terminations and consequences of medullitis, Pirogoff says, "According to the investigations of Demme, osteo-myelitis subsides into a condition characterized by an exuberant growth of the connective substance, chalky deposits in the same, narrowing of the medullary canal, and osteophytic *condensation* of the bone (sclerosis), more frequently than it terminates in *necrosis*. But I have never seen any other termination of *osteo-myelitis* than the unfortunate one in *pyæmia*." The author, however, trusts that, in the preceding pages, he has pointed out a considerable number of consequences of inflammation of the marrow besides pyæmia, and also that he has given a tolerably comprehensive view of this important branch of the subject. We also, to some extent, agree with Demme; for we believe that osteo-myelitis, when the term is used in a broad sense, ends in cure by resolution, or in the development of endostoses, with induration of the surrounding bone, much more frequently than in necrosis, or in osteo-porosis, or in caries, or in abscess of the marrow and pyæmia. We do not hear much said about the cases which recover without difficulty; but those which prove tedious, or troublesome, or fatal, produce a profound impression. We also believe that traumatic osteo-myelitis in general ends favorably, either by resolution, or by the production of endostosis, with condensation of the surrounding bone, unless the subject has an unsound constitution, or is held for treatment in the poisoned atmosphere of infected, unclean, or imperfectly ventilated hospitals or quarters, or his case is improperly managed in some other respect. We think that the traumatic form of this disease, when it occurs in persons of sound constitution, and placed under favorable circumstances, both hygienic and otherwise, for treatment, generally results, without difficulty, in recovery.

The author's conclusions.

Treatment of Osteo-myelitis. — The management of this disease must be considered in respect to that which is best adapted for the relief of the *acute* and *chronic* varieties of it respectively.

With regard to both the *acute* and the *chronic* forms of inflam-

mation of the medullary tissue, especially when produced by wounds or surgical operations, the fulfillment of certain sanitary conditions is demanded in order to secure success in their treatment. Foremost among these conditions is an adequate supply of pure atmospheric air for the use of the patient, together with cleanliness and quietude. The fulfillment of these conditions constitutes the *hygienic* treatment of osteo-myelitis.

Hygienic treatment.

To maintain an atmosphere suitable for the recovery of osteo-myelitic patients, it is necessary, in the first place, to scrupulously *avoid overcrowding*. The air should never be allowed to become vitiated with the *exhalations from human bodies*, as it assuredly must become, if the sick and wounded are crowded together in the rooms of private dwellings, or in the wards of hospitals. Each patient should therefore be allowed an air-space sufficiently large to prevent such a contamination of the atmosphere. When the treatment is conducted in houses, whether hospital buildings or dwellings, an air-space equal to at least twelve hundred cubic feet should be allotted to each patient. Fully as much attention should be paid to this subject when the wounded are treated in private quarters, as when they are treated in hospitals.

Exhalations from human bodies.

In the second place, contamination of the atmosphere by effluvia arising from soiled linen, dressings, or filth in any other form should be sedulously prevented. To this end the quarters of the invalid, including the floor, wall, and ceiling, the utensils, the bedding, the linen, and the person of the patient, should be kept scrupulously clean. Soiled dressings should always be removed from the room without any delay whatever. Special mention of this point is made becauses nurses and attendants are always disposed to overlook it.

Effluvia from soiled linen, etc.

In the third place, the atmosphere should not be allowed to become impregnated with the odors and other exhalations arising from suppurating wounds. This brings us to the subject of disinfectants; and here let me say that in my opinion there is no disinfectant at all comparable to the constant and rapid renewal of the air itself, to the constant displacement of the vitiated atmosphere of the hospital ward, for example, by the introduction of fresh air from the outside. Dr. Elisha Harris remarks that he considers the constant and frequent renewal of the atmosphere in hospitals, by means of properly constructed ventilating apparatus, to be a matter of quite as much importance as the avoidance of overcrowding, and the author fully coincides with him in that opinion. If, however, necessity compels the employment of disinfectants, the

Disinfectants.

chlorides of lime, soda, and zinc, carbolic acid, and the permanganate of potassa, will be found convenient for use, and among the most efficacious in results.

If the hospital buildings, or the dwelling-houses used for hospital purposes, chance to be crowded with patients, or if their construction is such that they cannot be properly ventilated, it is necessary to provide additional quarters. For this purpose it may be advisable to employ hospital tents,[1] since experience has shown that osteo-myelitic patients generally do remarkably well when treated in them. Care should be taken that the tents are pitched sufficiently far apart, and on such a general plan as permits the wind to circulate among them as freely as possible, and thus diminishes the tendency to ill effects from possible surface crowding. Hospital tents.

Again, the quietude of the patient is a matter essential not only to his comfort, but also to his recovery. Cases of osteo-myelitis, especially if the disease has an acute form, should not be subjected to transportation from one place to another. Such transportation, other things being equal, always does harm, and, in the writer's opinion, has not unfrequently induced a fatal termination in cases of this disease which otherwise would have resulted in recovery.

Internal Medication. — Osteo-myelitis, according to our experience, generally requires the employment of a tonic and supporting plan of treatment. It certainly does not, as a general thing, tolerate the depressing modes of treatment. The patient should be sustained by a diet consisting of such articles of food as are nutritious and easy of digestion. If the febrile movement runs high, it is advisable to administer saline drinks, such as the *liquor potass. citrat.* or the *liquor ammoniæ acetat.* suitably diluted.[2] In such cases, if there be much general irritability, advantage may sometimes be derived from the administration of *aconite* (tinct. rad. aconiti gtts. ii. q. q. h.) In order to procure Supporting treatment.

[1] I do not think that the surgeons connected with civil hospitals always appreciate sufficiently the advantages which may accrue to their patients, under certain circumstances, by removing them from the hospital wards and placing them in hospital tents properly pitched on suitable ground; and perhaps even military surgeons are not always sufficiently impressed with the value of this proceeding. It is true that there are several inconveniences and discomforts attending the treatment of patients in tents; but these are far more than counterbalanced by the benefit derived from the change by those surgical cases, especially, which are suffering from the bad effects of hospital atmosphere, or the foul air of hospital wards. It happened not unfrequently during the late war, that patients suffering from wounds and surgical operations, who were doing badly in hospital buildings, began to improve as soon as they were placed in hospital tents, and continued to do well afterward.

[2] Vide Case XXXIII.

relief from the pain, which not unfrequently is severe, either morphia, or opium, or some other preparation of that drug, should be administered in doses sufficient to accomplish this result. A very large proportion of the cases of osteo-myelitis which have come under our observation, have exhibited so much general debility as to require the administration of tonics from the commencement. Among the vegetable tonics we have found the sulphate of *quinia* to be the most valuable, and among the mineral tonics the preparations of iron, especially the *tincture of the sesquichloride* and the *tartrate of iron and potassa*. Not unfrequently the constitutional depression has been so great as to require the administration of alcoholic stimulants, such as porter, wine, whiskey, and brandy, and sometimes even in large quantity.

Mercury considered.

With regard to the exhibition of *mercurials*, I can only say that I have never met with a case of osteo-myelitis which seemed to require the protracted employment of this class of remedies. Furthermore, I have never seen a case of this disease, to which, in my opinion, the administration of calomel or any other preparation of mercury to the extent of ptyalism, would not have done positive harm. Mr. Stanley, however, recommends the employment of mercury internally with a view to produce its full influence on the system in treating acute inflammation of the medullary tissue. He considers calomel and opium as well suited for this purpose. But he admits that the acute affections of bone, which require active mercurial treatment, are comparatively rare.[1]

Iodide of potassium.

The *iodide of potassium*, however, constitutes a remedy of great value in the treatment of osteo-myelitis, especially the sub-acute and chronic forms of the disease. It should be administered in solution, and in doses of from three to five grains, four or six times a day. It can be conveniently exhibited, in many instances, dissolved in the fluid extract or the tincture of bark. Mr. Stanley has placed a very high estimate upon the utility of the iodide of potassium for the relief of inflammation of both the periosteum and the medullary tissue. The writer's experience coincides in the main with that of Mr. Stanley in the use of this remedy.

In treating the rheumatic, the gouty, the scrofulous, and the syphilitic forms of inflammation of the marrow, it should be remembered that each of them is connected with a peculiar diathesis, or dyscrasia, which requires the administration of remedies especially adapted to its alleviation or removal. Thus, to patients suffering from rheumatic osteo-myelitis in an acute form, we may

[1] Vide *Diseases of the Bones*, p. 45. Am. ed.

often give, with benefit, alkaline remedies, such as sal Rochelle, liquor potassæ, the carb., bicarb., and citrate of potass., etc., and if the vascular excitement be great, if the pulse be very strong and frequent, as it is apt to be in such cases, the veratrum viride may be advantageously employed to reduce it. If the disease be complicated with the gouty diathesis, the administration of colchicum will prove beneficial, since this remedy appears to be about as much a specific for the relief of a paroxysm of gout as quinine is for a paroxysm of intermittent fever. The successful treatment of scrofulous osteo-myelitis requires the employment of a nutritious diet, the administration of iodine or its compounds, such as the iodide of potassium and the iodide of iron, the use of cod-liver oil, and perhaps also some of the vegetable tonics, such as prunus virginianus, quassia, gentian, or bark, together with change of air and scene. To relieve the syphilitic form of osteo-myelitis, it is necessary to persevere in the use of the iodide of potassium above all other remedies. In some cases the disease will not yield until it is given in very large doses. To such patients it may be found advisable to administer this medicine in what are called increasing doses. I have treated, on this plan, one case in which relief from distressing syphilitic pain in the tibia was not obtained until ninety grains of potass. iodid. were administered per day, and the relief was not complete until one hundred and twenty grains were taken daily.

Again, the presence of a *scorbutic taint*, in a patient suffering from osteo-myelitis, should not be overlooked, for the cure of the latter can be facilitated by the removal of the former. To this end the antiscorbutic treatment must be employed. A nourishing diet, consisting mainly of fresh meat and fresh vegetables, must be allowed; and lime-juice, or the juice of lemons, together with the salts of potassa, especially the citrate, tartrate, or chlorate, should be administered internally. In some cases it will be found beneficial to the patient to prescribe the tartrate of iron and potassa.

Topical Medication. — The part affected with the disease should be placed in such a position as does not favor the afflux of blood to, or its stagnation in, the diseased tissue. At the same time, if suppuration be present, the posture should be such as favors the outflow of the pus. An osteo-myelitic member should therefore be placed in an *elevated position*, with the orifice for purulent discharge dependent. The diseased member should also be disturbed as little as possible by moving it or changing its position, or, in other words, it should be kept as *quiet as possible*. Local medication.

The *local abstraction of blood*, by leeches or cups, may also be found useful, especially in cases where the disease has a sthenic type, and is in an early stage of its development. But such cases were not often met with among the wounded who came under my observation during the late war. This means of subduing inflammation should, however, not be overlooked by the surgeon while considering the line of treatment to be followed during the early stages of osteo-myelitis.

Cold applications.

The *abstraction of heat* from an inflamed part by the *application of a cold body* to it is generally recognized as a valuable means of modifying the inflammatory process. Among the most potential of all the modes in which the topical application of cold can be effected, is that of the *ice-dressing*. It has often been employed by the writer personally, or under his immediate direction, and generally with decided benefit. The ice should be broken into small pieces, and placed in a bladder or a bag made of india-rubber, in order to prevent any discomfort or damage to the patient which might arise from the wetting of the bed through the melting of the ice. Sometimes the ice-dressing is objectionable on account of its weight. In such cases the *irrigation of the affected parts with ice-water* may be advantageously employed. Sometimes a degree of cold as intense as that of ice or ice-water proves uncomfortable to the patient. In such cases the application of the ordinary *cold-water dressing* may prove beneficial. Occasionally the application of cold in any form causes a sensation of general chilliness, or is disagreeable to the patient in some other way. In such cases the employment of *warm applications* to the affected part will be found to produce a soothing and beneficial effect.

Warm applications.

The moist warmth may be applied through the agency of the warm water dressing, or by means of poultices; but the former is incomparably more cleanly and seemly than the latter, and on that account is generally to be preferred. With regard to the application of cold or warmth to the seat of the disease, in the treatment of acute osteo-myelitis, the *sensations of the patient* afford an unerring guide. If the cold applications are grateful to the patient, and lessen his sufferings, their use should be persisted in; but if, instead of affording relief, they produce positive discomfort, warm applications should be employed in their stead.

Again, in the advanced stages of acute osteo-myelitis, or in cases where that variety of the disease has subsided into a sub-acute or chronic form, the external application of the *tincture of iodine* over the seat of the disease often proves beneficial. It seems to do

good, firstly, by the effect of the iodine, which is absorbed, upon the diseased tissues themselves, and, secondly, by the counter-irritation which may be established by its action on the skin. The part should be extensively painted every day with this remedy until the skin becomes sore, when its application every second or third day will generally suffice. It may also be advisable to produce vesication, in some cases, with *emplast. cantharidis*, for the purpose of obtaining more decided counter-irritation.

Operative Medication. — Incisions into the inflamed soft parts down to the bone may often be advantageously made in treating this disease. They always afford more or less local depletion. They are always required when accumulations of purulent matter (abcesses) in the soft parts are formed; and, for the relief of such a condition, should be made at an early period, — indeed, the earlier the better, as a general thing, after the presence of pus has been detected. Osteo-myelitis, when it occurs spontaneously, is very apt to be accompanied by diffuse inflammation of the soft parts, which, to a greater or less extent, masks the real nature of the disease. In all such cases, *free incisions*, made down to the bone, are very advantageous. They relieve the painful tension of the soft parts at once, and, at the same time, evacuate any purulent matter that may have been formed between the periosteum and the bone, if that membrane should chance to be detached. Even in cases where the diagnosis is doubtful, and the soft parts are in a state of diffuse inflammation, it is considered to be good practice to cut down to the bone, in order to ascertain, firstly, whether the periosteum is separated from the bone, and, if it is, the extent of said separation; secondly, the condition of the bone itself; and, thirdly, whether the deep-seated pain can be relieved in this way; for a knowledge of these points affords material assistance in framing a diagnosis.[1]

Free incisions.

The clinical histories of the next two cases, both of which occurred in the author's practice, furnish illustrations of the great value of free incisions in the treatment of osteo-myelitis. In both of them the disease followed gunshot fracture of the femur; and it is believed that the patients ultimately recovered.

CASE XLV. *Gunshot Fracture of Left Femur and also of Cranium; Necrosis and Exfoliation of a Fragment of External Table of Skull; Chronic Osteo-myelitis of Femur; Several Fragments of Necrosed Bone, besides some Detached Splinters, extracted from Thigh; Recovery with*

[1] Vide the discussion concerning the diagnosis of osteo-myelitis.

Three Inches' Shortening; Value of Free Incisions exhibited in the Treatment. — Sergeant John Peters, Co. I, 115th Pennsylvania Vols., aged 25 years, was admitted to the Stanton U. S. Army General Hospital, on the 15th of June, 1863, for gunshot injuries. He stated that he was wounded on the 3d day of May in the battle of Chancellorsville by a minie ball, which passed through his left thigh in a backward and outward direction, and caused a compound comminuted fracture of the femur in its middle third. When admitted to the hospital, six weeks after the reception of the injuries, the limb was on a double inclined plane, the ends of the bone overlapped each other some two or three inches, the thigh was swollen and inflamed, and the wound suppurating profusely. There was also a large excoriation in the popliteal region, caused by the pressure of the splint.

He had besides a compound comminuted fracture of the skull, located in the superior part of the frontal bone near the coronal suture, and on the right side of the median line. The scalp-wound was about two inches in length and one in breadth. The depressed portion of the bone was about the size of a half-dime. All the bone lying at the bottom of the scalp-wound was denuded of the pericranium. The scalp-wound now is rather dry, and secretes but little pus. He states that his left side was paralyzed for about two weeks after the reception of the wound. He can move his left arm freely now, but no opinion can be formed with regard to the paralysis of his lower extremity, because the left thigh is fractured. He complains of having some frontal headache, and pain shooting in the direction of his right eye. He has no other head symptoms. His general condition is not promising. His tongue is red and dry, his pulse frequent and feeble, his spirits are somewhat depressed, and he has but little appetite. Treatment: the limb was placed in Hodgen's splint, the water dressing applied to the wounds of both the thigh and the head, and porter with a generous diet allowed.

June 17. — He had a chill, followed by fever and sweating. Prescribed quiniæ sulph. grs. x. in solution.

June 20. — His general appearance has improved. The head-wound looks well. The denuded bone is bathed in healthy pus. The thigh-wounds also are doing well.

June 25. — The wound of the head has ceased to suppurate, and the bone lying at its base is dry and white. He also has slight headache and some fever. Prescribed quiniæ sulph. grs. v., acid. sulphuric. aromat. gtts. x., to be taken three times a day.

June 27. — The wound of the head is again suppurating, and he has no fever. Removed from the thigh a detached fracture-splinter about one inch in length.

July 1. — The discharge of pus from the wounds in the thigh is profuse. He looks pale and anæmic. Prescribed tinct. ferri muriat. gtts. xx., to be taken three times a day.

July 12. — He complains of having pain in the foot, which prevents sleep. Directed morphiæ sulph. gr. ½ to be administered at night.

July 18. — He has diarrhœa. Prescribed pil. opii (gr. i.) et camphoræ (grs. ii.), to be taken every three hours.

July 25. — He has loose stools occasionally, which are controlled by the use of opium.

July 28. — Removed another detached fracture-splinter from the thigh.

August 10. — His general condition is much improved. The head-wound looks well. The fracture of the femur has united; but necrosed bone is discernible on exploration of the thigh-wound.

August 30, 31, *and September* 2. — He had rigors and fever in the afternoon. He took quiniæ sulph. grs. x. three times a day.

September 5. — He complains of pain in his right side, is restless, has cough, and there is coarse crepitation in his right lung. The pus discharged from the thigh-wounds is profuse and fetid. He is very feeble. Ordered a jacket poultice to be applied to his chest, an expectorant mixture containing carbonate of ammonia, together with milk punch, to be taken internally, and the thigh to be dressed with liquor sodæ chlorinat. dilut. as a disinfectant.

September 8. — His condition is much improved. The pain, cough, and crepitation in the chest have ceased. An exfoliation consisting of the outer laminæ of the external table of the skull, three fourths of an inch in length by four tenths of an inch in breadth, was removed from the head-wound to-day. Prescribed acid. phosphoric. dilut. gtts. xx., to be taken every six hours.

September 11. — There is swelling, redness, and pain in his thigh. Ordered the lead and opium wash to be applied to it.

September 12. — The pain, redness, swelling, and tension of his thigh have increased. *Free incisions were made* (*long and deep*), *a quantity of pus evacuated, and relief afforded.*

September 14. — His general condition is much improved. The swelling and inflammation of the thigh is much diminished.

September 20. — Wound of head is healed; abscess of thigh filling up with healthy granulations.

October 1. — A small abscess has formed in the external side of the thigh; *incised it.*

November 1. — There are now three sinuses leading down through the soft parts to the femur at the place of fracture. Dead bone can be felt at the bottom, but it is not loose. His general condition is excellent.

December 15. — A small abscess has formed in the outer side of the thigh; opened it.

December 20. — He complains of debility and want of appetite; is pale and anæmic, and the thigh continues to discharge freely. Prescribed

extract. nucis vomicæ gr. $\frac{1}{6}$, ferri et quiniæ citrat. grs. iii., to be taken three times a day.

January 18, 1864. — Extracted a large fragment of necrosed bone from the thigh through the anterior wound.

February 13. — He has diarrhœa. The evacuations are profuse and fetid. Prescribed ol. ricini f. ʒi. tinct. opii. gtts. xxx. dose.

February 14. — The diarrhœa continues. Ordered pil. opii (gr. i.) et camphoræ (gr. i.) to be taken after each stool.

February 16. — The diarrhœa is checked. Prescribed tinct. ferri muriat. gtts. xx. to be taken three times a day, as he is weak and anæmic.

February 22. — Removed a loose fragment of necrosed bone from the thigh.

March 28. — Again removed a loose fragment of necrosed bone, and through the posterior wound. The anterior wound is granulating finely. Considerable necrosed bone can still be felt through the posterior wound, but it is not loose.

April 14. — The patient was transferred to Philadelphia, Pa., being in good flesh and spirits, and abundantly able to stand the journey. The injured limb is recovering from the atrophy occasioned by long disuse, that is, it is increasing in size, and the patient is rapidly regaining the use of it.

The limb was shortened just three inches.

Besides attesting the value of free incisions, this case also illustrates in a general way the subject of the treatment of osteo-myelitis and several of its consequences or complications.

No improvement until incisions were made.

It is worthy of remark that this patient did not begin to improve decidedly till free incisions in the diseased thigh were employed.

Case XLVI. *Gunshot Fracture of Left Femur, high up in Upper Third, followed by Chronic Osteo-myelitis of a very Dangerous Character, but, after a Long Time, terminating probably in Recovery.* — Private Ludwig Wolfsen, Co. C, 40th New York Vols., 23 years old, and of very vigorous constitution, was wounded in the battle of Chancellorsville, May 2, 1863, by a minie ball, which passed through the left thigh in its upper third obliquely, from within outwards and somewhat from before backwards, producing a compound comminuted fracture of the femur high up in its upper third. He was admitted to the Stanton U. S. Army General Hospital June 15, having previously been treated in the Field Hospital at Potomac Creek. His general condition was still fair, although there was a copious discharge of pus from the posterior orifice of the wound. When he was brought to the Stanton Hospital he had a long straight splint on his broken thigh, or, in other words, the limb was dressed with a long straight splint. This splint was now removed,

and the limb placed in Hodgen's apparatus, a moderate amount of extension employed, the water dressing applied to the wounds, and he was directed to have a nourishing diet, with alcoholic stimulants, and an opiate administered at night to insure sleep.

July. — During this month no symptoms of a remarkable character showed themselves. His appetite, etc., continued good.

August 1. — He has slight diarrhœa, — from two to four passages a day; prescribed pil. opii gr. i. after each stool.

September 1. — Removed the splint of Hodgen, and found the callus very abundant, hard, and firm. Measurement showed the amount of the shortening to be three and one fourth inches.

September 12. — The discharge from the posterior wound (orifice) is thin and fetid. On examination with a probe, necrosed bone can be detected; prescribed tinc. ferri muriat. gtts. x., to be taken three times a day, with nutrients, stimulants, etc.

September 25. — He has occasional chills; also a bed-sore over sacrum; directed him to be placed on a water-bed, the wounds to be dressed with simple cerate spread on lint, and quiniæ sulph. grs. x., to be administered three times a day.

September 27. — The chills are stopped.

October 10. — The anterior orifice of the wound opened this morning, and discharged a thin sanguineous pus.

October 18. — He has diarrhœa, — three or four motions daily; treated it with opiates, but it continued till October 26.

November 1. — There is diffuse inflammation involving over half of the thigh. He has profuse nocturnal sweats, with much constitutional disturbance. Prescribed the lead and opium wash for the thigh, and quiniæ grs. v., acid. sulphuric. aromat. gtts. x., to be taken three times a day; stimulants, nutrients, etc., to be continued.

November 5. — *Made several openings* in the anterior part of the thigh, *by incision*, for the exit of pus. Afterwards his general condition improved, and the nocturnal sweats, along with the local inflammation subsided.

December 1. — He had a severe chill this morning. The limb around the seat of fracture presents a swollen, doughy appearance. The discharge from the wound is thin, dark-colored, and profuse. *Made an incision on the outer side of the thigh, four inches in length, down to the bone;* and prescribed quiniæ sulph. to be taken in full doses.

December 2. — He had a slight chill about noon. There is a free discharge from the incision made yesterday. Prescribed the following mixture: ℞ tinct. ferri muriat. f. ʒi. quiniæ sulph. ℈i., aquæ fontan. f. ʒviii., M., of which a table-spoonful is to be taken three times a day.

December 10. — Gradual improvement; chills stopped; appetite better.

January 30, 1864. — There is but little change in his condition; he sits up occasionally.

February 20. — Patient gaining flesh rapidly, and improving in every respect.

March 15. — He now walks with the aid of crutches, and a bandage suspending the limb from his neck.

April 10. — He continues to improve rapidly in every way.

May 10. — He was transferred to Philadelphia, Pa., still progressing satisfactorily.

Free incisions as useful in the acute as chronic forms.

The relief afforded by free incisions in this case was very decided and very gratifying. We may also state here that free incisions generally prove fully as valuable in treating the acute as the chronic forms of this disease. We have been led to make this remark because both of the foregoing cases were examples of the chronic variety of inflammation of the marrow.

Trephining in chronic abscess of bone.

Again, *the operation of trephining* has not unfrequently been practiced with benefit in the treatment of inflammation of the medullary tissue. In the form of this disease usually denominated *chronic abscess of bone*,[1] the evacuation of the purulent matter by means of this operation is the only way to get a cure short of amputation. It also appears that the trephine has sometimes been usefully employed in treating inflammation of the medullary tissue of a more active form, especially when it involves the cranial bones. Mr. Abernethy states that when matter is formed in the diploe, the pericranium will certainly separate from the bone, and the external table of the skull undoubtedly perish. In a case so clearly marked, the conduct to be pursued is obvious, which is to remove a portion of the external table with the trephine, so as to discharge the matter collected in the diploe, without which no relief can be obtained. He also says he has seen, in several instances where the operation was performed early, that the external table came away in the crown of the trephine, the matter was discharged from the medullary part of the bone, and the internal table remained sound and entire, covering the dura mater. Granulations soon arose, and the patients got well, with the exfoliation only of a portion of the outer table. The mischievous consequences of delaying this operation, when once the disease is known, are evident; for the matter collected within the bone, having no outlet, will press on every side, first gradually destroying the diploe, some-

[1] The seat of chronic abscess of bone is almost always the articular extremities of the long bones which form the great joints, the knee, ankle, and elbow. The tibia is more frequently affected than any other bone, and usually at its upper end. The lower end of the femur is the next in point of frequency.

times extending itself over a large portion of the cranium, and at last occasioning the skull to be perforated with a number of holes, like a piece of worm-eaten wood. These holes afford a way of escape to the matter, which not only oozes out beneath the pericranium, but also insinuates itself between the skull and the dura mater; till at length the patient sinks, worn out by the irritation and fever which this painful and extensive disease creates; unless, as sometimes happens, he is previously destroyed by inflammation attacking the membranes of the brain. The surgical procedure obviously demanded by this pathological condition of the cranium, is the early trephining of its outer table.[1]

Duverney states that in two cases where matter was imprisoned in the osseous tissue, it was necessary to perforate it with a trephine.[2]

In two cases of suppurative osteo-myelitis, accompanied by spontaneous perforation of the walls of the tibia, Hey enlarged the hole in the bone with a trephine, and removed all the diseased tissue from the medullary canal. He obtained a good result in both cases.[3] In one instance Langston Parker found it necessary to trephine the tibia for the relief of syphilitic osteo-myelitis.[4]

Amputation.

Again, the *amputation* of the diseased member has several times been successfully employed in the treatment of osteo-myelitis involving the bones of the extremities. Of seven cases of this disease related by Mr. Stanley, three appear to have been saved by that operation. The arm was amputated in one instance for disease of the elbow-joint, and the thigh in the other two for disease of the leg. Besides these three, one case recovered without operation. A large portion of the tibia exfoliated, and the knee-joint became permanently anchylosed. In this case the pain, which was very great, and the inflammatory fever, which ran very high, and was accompanied by delirium, were all relieved by the bursting of a large abscess a little way below the knee. Could not relief from these distressing symptoms have been obtained at an earlier date by making a free incision? In the remaining three of Mr. Stanley's cases, no operation was admissible, and they terminated fatally. In all of Mr. Stanley's cases the disease was not traumatic in origin. Gooch also has reported a case of osteo-myelitis of the tibia which was cured by amputation of the thigh.[5]

[1] Vide Abernethy's *Surg. Obs.* vol. ii. pp. 68, 69. Am. ed., 1811.
[2] Vide *Traité Pratique d'Anatomie Médico-chirurgicale*, par A. Richet, p. 61. Paris, 1860.
[3] Vide Case XXI. [4] Vide Case XIX. [5] Vide Case XXII.

It should be observed that in these four successful cases the operation was performed at a point where the medullary tissue was entirely sound, and in a part of the member which was not involved in the disease. In three of them the thigh was amputated for osteo-myelitis of the tibia.

The following is the history of one of Mr. Stanley's successful cases.

Case XLVII. *Suppurative Inflammation (acute) of the Medullary Tissue of the Tibia, including that of its Shaft and Epiphyses; Consecutive Pyarthrosis of both Knee and Ankle; Necrosis of the Whole Bone; Amputation; Recovery; the Disease followed Sprain of the Ankle and Exposure to Wet.* — A youth, 18 years of age, was brought from the country to St. Bartholomew's Hospital, with the following history of his case: that six weeks previously he sprained his ankle, and on the following day had lain on the wet ground, with a powerful sun shining on him. On the next day the whole leg became red, swollen, and painful. A few days afterwards a large quantity of matter was discharged by incision near the ankle, and other openings for the same were subsequently made near the knee. The suppuration extending through the leg, had been accompanied by the most severe constitutional derangement. A probe being passed through the openings in the soft parts to the tibia, this was found to be denuded of periosteum through its entire length and circumference. The knee and ankle joints were acutely painful. The boy was emaciated, his countenance flushed, his pulse very frequent and feeble, his nights sleepless from pain. I felt certain that the primary disease had been inflammation of the medullary membrane of the tibia, from the severity and rapid progress of the symptoms, and especially from the extension of the inflammation through the articular ends of the bone to the joints of the knee and ankle. A week after the admission of the boy into the hospital, it became evident that amputation of the limb afforded the only chance of preserving his life. In consequence of his exhausted state, I did not venture to remove him from the water-bed upon which he lay, but drew him to the edge of it, and there removed the limb. His recovery was complete.

On examining the limb, I found purulent fluid in the knee and ankle joints, with the almost complete destruction of their articular cartilages. The shaft of the tibia, in its whole extent, was denuded of periosteum; but that membrane was entire, except in the spots where incisions had been made through it for the discharge of matter. The inner surface of the periosteum was extremely vascular, so soft and velvet-like as to resemble acutely inflamed conjunctiva. Through the medullary tube and cancellous tissue of the bone, there were deposits of thick, purulent fluid. The walls of the bone were nowhere perforated; hence the certainty

that the purulent fluid found within it was the product of inflammation in the medullary membrane. The epiphyses at both ends of the tibia were loosened by suppuration between them and the shaft. A commencing line of separation at each end of the bone, near the epiphyses, indicated that the shaft had perished. This, indeed, was to be expected, as the consequence of inflammation in the medullary membrane and in the periosteum, with the entire separation of the latter from the bone.[1]

Amputation.

But experience has shown that when this operation has been performed in the continuity of a bone invaded through its whole extent by osteo-myelitis, the results are very unsatisfactory. Secondary amputation under these circumstances proved very fatal in the hands of T. Vallette during the Crimean War, of Jules Roux at Toulon in 1859, and in the hands of our own surgeons during the late war. Indeed, it is probable that this circumstance affords, in part at least, an explanation of the very high rate of mortality which generally attends secondary amputation for gunshot injuries. The inflammatory process having been kindled in the medullary tissue through the whole extent of the shaft of the femur, for example, and a state of hepatization of the marrow having already been produced when amputation is performed, the disease advances rapidly to the stage of suppuration in the stump-bone after the operation, with much greater rapidity, probably, in a majority of instances, than it would have done if the operation had not been performed. That is precisely what happened in the history of the following case, wherein amputation was performed in the continuity of a humerus, the medullary tissue of which was hepatized or involved in the first stage of the inflammatory process at the time of the operation. Afterwards the disease rapidly advanced to the stage of suppuration in the stump-bone, and the patient died on the twelfth day, of pyæmia.

Amputation in continuity not advised.

Case XLVIII. *Fracture of Humerus from Railroad Casualty; Hepatized Marrow; Non-union of Fracture; Amputation of Arm; Purulent Osteo-myelitis of Stump-bone; Death with Symptoms of Pyæmia on the Twelfth Day after the Operation.*—A young man, aged 19, and of healthy appearance, sustained a fracture of the left humerus from railroad machinery, together with a good deal of injury of the hand and fore-arm, especially of the soft parts pertaining to them, and was brought to one of the metropolitan hospitals in New York. His case did not progress favorably. There was no attempt at union of the fracture; the whole limb continued to be greatly swelled, and foul pus burrowing extensively among its muscles, his general health declined, and it be-

[1] Vide Stanley on *Diseases of the Bones*, pp. 32, 33. Am. ed., 1849.

came necessary to remove the diseased member as a remedial measure of last resort. Accordingly the arm was amputated November 20, 1865, about six weeks subsequent to the receipt of the injury. Sulphuric ether was employed as an anæsthetic. The amputation was performed a short distance only below the surgical neck of the humerus. Examination of the amputated member showed that so far as the fracture was concerned, there was no attempt whatever at union, that the lower end of the proximal fragment was nicely rounded off, that the periosteum in this locality was redder and denser than natural, that there was a small deposit of new bone, in the form of *periostosis*, in the same locality; and on splitting the piece with a saw, the medullary tissue was found to be *inflamed* and *hepatized*, and there was an abundant deposit of new osseous tissue in the cavity of the medullary tube, *endostosis*, especially at and near the fractured end.[1] The old osseous tissue itself had acquired a rosy hue in the same locality, from inflammation (*ostitis*).

A *microscopical examination* of the specimen was made by Prof. J. W. S. Gouley, assisted by the author, and with the following result. A portion of hepatized marrow taken at random, and examined under No. 5, objective, and No. 1, eye-piece of Nachet, exhibited the following appearance: a number of fat vesicles, twenty-five at most, was counted in the field; they varied in size from the 1000th to the 200th of an inch in diameter; all the interspaces were filled up with granular nucleated cells and blood corpuscles; the latter were few in number. The nucleated cells ranged in size from three to five times that of a blood corpuscle. They were mainly spherical in shape, but some were irregular from mutual apposition. The nuclei were mostly round, but some were oval, and they had generally twice the size of a blood corpuscle. They contained from one to two nucleoli, and were best seen on the addition of a drop of dilute acetic acid. No fusiform cells were found. Here and there a capillary vessel was seen, but unaccompanied by any fibrous tissue. The granular nucleated cells were at first taken for pus corpuscles; but on the addition of dilute acetic acid, it was found that they did not react as pus.

Next, a piece was taken from the centre of the medullary canal, where it appeared to be undergoing ossification, or, indeed, was already ossified. This new osseous tissue had a yellowish-white color. On examining it with the same power, all the cellular elements above mentioned were found, together with numerous lacunæ, showing that the process of ossification was going on. The lacunæ were arranged with their long axes parallel to each other, and in a portion of the specimen the histological elements presented a somewhat laminated appearance.

No parent marrow cells were discovered. The red color of the marrow appeared to be due, for the most part, to increased vascularity.

Why was the hepatized medullary tissue denser and more consistent than the healthy marrow in this case? It should be remembered that

[1] Vide Plate VIII.

no fibrous tissue nor fibre cells were found. To what, then, could the induration of the marrow be ascribed besides *sclerosis of the intercellular substance?*

The patient did not do well after the operation. He finally exhibited the usual symptoms of pyæmia, and died at midnight Friday, December 1st and 2d, on the twelfth day after the operation.

Autopsy. — The stump-bone was found to be involved with suppurative osteo-myelitis, on dividing it longitudinally with a saw. Its medullary tissue was seen to be extensively destroyed, and the medullary spaces and cancelli extensively filled with a dirty, ash-colored, fetid pus.[1] The periosteum was thicker and redder than natural.

The internal organs were not examined.

Microscopical Examination of the Stump-bone. — A specimen taken from the midst of the gray surface of the section, and examined with the same power as on a previous occasion, was found to contain a large quantity of granular matter, the debris of decomposed pus corpuscles, with here and there a pus corpuscle itself. Occasionally a medullary cell also was seen; such cells were granular; their nuclei were large and granular also.

A specimen taken from one of the large cancelli on the border of the gray surface where it joins upon the red, contained a number of fat vesicles with a large quantity of free oil in the form of very minute globules.

On making a thin transverse section of the compact tissue of the stump-bone, and examining it with a hand-glass, the Haversian canals were seen to be enormously enlarged, especially near the periphery (circumferential laminæ). In this situation they were so much enlarged as to be easily seen with the unaided eye. These enlarged medullary spaces were stained with the coloring matter of blood.

Comments. — The microscopical examination showed conclusively that the sclerosis of the hepatized marrow was not produced by the development of new connective tissue, for no fibre cells were found. It also showed us, in a beautiful manner, the point which had been reached in the transformation of hepatized medullary tissue into new osseous tissue (endostosis).

At the time the amputation was performed, it is certain that the medullary tissue was inflamed, not only in the part of the humerus which was excised, but also in that which was left in the stump. The consequence of this was, that after the operation, the osteo-myelitis of the stump-bone rapidly advanced to the stage of suppur-

[1] Vide Plate IX.

ation, and, on the twelfth day, the patient died of pyæmia. In the opinion of the author, there is no doubt but that this man's chance of recovery would have been decidedly better if the limb had been exarticulated at the shoulder instead of being subjected to amputation in the continuity, for, by so doing, all the diseased medullary tissue would have been removed, and the occurrence of pyæmia from suppurative osteo-myelitis would have been entirely prevented. This case, therefore, teaches an important practical lesson, to wit, that exarticulation ought be practiced, instead of amputation, in all similar cases.

Ought to have been exarticulated.

Exarticulation of the Diseased Member for the Cure of Osteo-myelitis. — Dr. T. Vallette, to whose memoir reference has already been made, was the first to suggest the substitution of the operation of exarticulation for that of amputation in the continuity of the diseased bone, in the treatment of the acute forms of osteo-myelitis. He did it in 1855. He found that all his attempts to arrest the progress of this variety of the disease by secondary amputation or resection of the injured bones were ineffectual; and he therefore recommended that these operations should be abandoned, and exarticulation employed in their stead, in the treatment of acute osteo-myelitis following gunshot fractures. Dr. Jules Roux was brought to the same conclusion by his experience in treating the sub-acute and chronic varieties of this disease in 1859. At first he practiced amputation, but the results were very unfavorable. Of five cases of secondary amputation of the thigh and leg performed in the continuity of the diseased bone, four died, and but one recovered. This want of success induced him to make trial of exarticulation of the diseased member in its stead, the osteo-myelitic process being of such a character as to demand the employment of some operative procedure in order to save the patient's life. The operation of exarticulation proved remarkably successful in his hands, and those of his colleague at the St. Mandrier Hospital. In twenty-two successive cases, four of which were exarticulations of the hip, no death occurred.[1] M. Roux argued that when inflammation of the medullary tissue, resulting from gunshot injury, assumes a chronic form, amputation in the continuity of the diseased bone generally takes away only a portion of the morbid marrow, and that, in consequence of the incompleteness of the operation, the disease is aggravated in the remainder. This is precisely what happened in the case last re-

Exarticulation preferred by Vallette and Roux.

[1] Vide *Mémoires de l'Academie Impériale de Médecin*, t. xxiv. p. 590.

lated,[1] as we have already pointed out. We are therefore prepared to express the belief that in cases of diffuse osteo-myelitis produced, not only by gunshot wounds, but by any cause whatever, amputation performed in the continuity of the diseased bone, for the most part, does not take away the whole of the inflamed marrow, and that, in consequence of this failure to obey the surgical axiom which requires the removal of the whole of the diseased tissue, which renders an operation necessary, the inflammation of the medullary tissue in the stump-bone is usually much aggravated, and goes on to a fatal termination in a large majority of instances. For the cure of such cases the only rational surgical procedure is to remove the whole seat of the disease, either by exarticulation, or, when the leg or the forearm is the seat of the disease, by amputation performed in the continuity of the sound thigh or arm. If the femur or the humerus be the seat of diffuse osteo-myelitis, and it be necessary to operate, then exarticulation should be practiced at the hip or the shoulder according to the case; but if the bones of the leg or the forearm are the seat of the disease, and it be necessary to operate, then the surgeon may exercise a choice between exarticulation at the knee or elbow, and amputation in the continuity of the sound femur or humerus. It is also worthy of mention in this place that the only patient out of four who was saved by M. Chassaignac, underwent exarticulation at the shoulder.[2]

Remove all of the diseased tissue.

Prof. Van Buren has recently performed exarticulation at the knee for acute suppurative osteo-myelitis of the tibia, with a good result. The following is an account of the case.

CASE XLIX. *Acute Osteo-myelitis of the Tibia in a Young Subject, Occasioned by a Fall; the Disease did not appear immediately; Necrosis mostly central; Spontaneous Separation of the Upper Epiphysis; Abscess of the Marrow; Exarticulation at the Knee performed by Professor Van Buren; Recovery.* — A delicate young girl of 11 years, whose mother died of mammary cancer, slipped on the ice while sliding, and struck her knee, early in January, 1866. She got up, however, and resumed her play. On the following day she went to school. There was no appearance of a bruise. She remained apparently well for about two weeks. Then she was seized with severe pain in the leg a little way below the knee, and in three or four days local swelling supervened. In two or three days more, the swelling extended to the whole leg. It was

Dr. Van Buren's case.

[1] Case XLVIII.

[2] Vide *Traité Pratique de la Suppuration*, p. 495, t. i.; vide also Case XX.

flat-shaped (not pointed), doughy, œdematous (pitted under pressure), and was not reddened, but pale in color. The case was supposed to be one of phlegmonous erysipelas. Fluctuation was perceived a little way below the tubercle of the tibia, and, on making an incision, about two ounces of pus were evacuated. On the third day afterwards it was noticed that the purulent matter discharged, presented an oily appearance, or seemed to contain globules of oil; and subsequently the oily condition of the discharge continued.

March 2, 1866. — The patient was seen by Dr. Gouley and Prof. Van Buren. Examination then disclosed the fact that a sinus, through which pus was discharged, extended downwards and backwards into the tibia, and dead bone was felt at the bottom of it. The leg was flexed upon the thigh to a right angle, and the thigh was also bent upon the trunk. The suppuration was profuse. The patient was irritable and restless, and got very little sleep at night, even with the use of opium in full doses. The leg was very painful, and affected with twitchings and startings. The pulse was irritable and frequent, being constantly above 120, and sometimes as high as 140. Her health was failing. Further examination of the limb revealed a *point of abnormal motion*, near the upper end of the tibia, which was occasioned by a *spontaneous separation of the superior epiphysis* from the shaft of that bone.

March 5. — The leg was exarticulated at the knee. The operation was performed by Prof. Van Buren. The foot and leg were moderately swelled at the time.

The *autopsy of the member* showed that the marrow was inflamed throughout the shaft of the tibia, that it was suppurating in the upper and the lower portions, and was hepatized in the middle,[1] that the cartilage of union with the upper epiphysis had disappeared almost entirely, and its place was occupied by soft granulation tissue, so that free mobility at that point was allowed; that the compact tissue of the tibia was necrosed at and below the tubercle through a space two inches long; that the internal laminæ, or those surrounding the marrow, were necrosed to a very much greater extent (central necrosis) than the circumferential laminæ, that there were several fragments of necrosed bone in the upper part of the shaft, the epiphysis being healthy;[2] that the exterior of the tibia exhibited a considerable number of isolated, reddish-colored granulations of new bone shooting out from it (exostosis);[3] that the periosteum generally was redder and thicker than natural; and that the longitudinal grooves belonging to the exterior of the bone, were, in general, much broader and deeper than natural.

Dr. Gouley, to whom I am indebted for the plates, and for the notes of the case, has informed me that the histology of the marrow was essentially the same as we have seen in other cases of osteo-myelitis.

[1] Vide Plate X. [2] Vide Plate X. [3] Vide Plate XI.

March 23. — I had an opportunity to examine the patient through the kindness of Dr. Gouley. She was doing well. The stump was healing by granulation. The cartilage of incrustation did not necrose, but had become converted into new red granulations, through almost all its extent. This is an important fact in the pathological history of this case. The patient recovered.

Comments. — This case presents several points of very great interest. They embrace certain of the symptoms which attended the development of the disease, the pathological conditions which it produced, and the method that was adopted for its removal. Among the most characteristic of the symptoms were the flattened shape, and the pale, doughy, œdematous appearance of the swelling, together with the presence of drops of oil in the purulent discharge. The swelling was coextensive with the inflamed marrow, and the oil-globules in the pus denoted that some tissue in relation with the bone — either the marrow or the periosteum — was the seat of suppurative inflammation. The relation which exists between the shape and appearance of the swelling of the soft parts, together with the presence of oil-drops in the purulent matter discharged, and osteo-myelitis, has already been pointed out.[1] This case attests the correctness of what is there stated.

Shape of swelling and drops of oil.

The spontaneous separation of the epyphisis constitutes another very interesting feature of this case. It was effected through the transformation of the cartilage of agglutination, by which the epiphysis was originally united to the shaft, into new, soft, red, granulation tissue (marrow), under the excitation of its histological elements occasioned by the inflammatory process. The spontaneous separation of the epiphysis of a long bone, by virtue of a pathological process, is an occurrence which has not often been described. So far as the writer knows, the only instances of this phenomenon on record besides this one, are thirteen cases which Dr. Hermann Klose, of Breslau, has described; and two additional cases, an account of which M. Gosselin published in the "Archives Générales de Médecin," for November, 1858. The thirteen cases which Dr. Klose saw, all occurred within eight years, and in young persons. They were thus distributed: one in the humerus at the elbow; one in the ulna, at the elbow; four in the tibia (three at its upper, and one at its lower epiphysis); and seven cases in the femur, at the knee; showing that the knee is by far the most exposed to this affection, since, of

Spontaneous separation of epiphysis.

[1] Vide *Symptoms of Osteo-myelitis.*

these thirteen cases, ten occurred in that situation. This kind of separation of the epiphysis never arises independently, but always occurs as a consequence of osteo-myelitis; at least, it never appears except in the course of that malady. We have already seen that such a relationship obtained in the case just related. Dr. Klose takes substantially the same view, for he says, "This disease is always preceded by an *inflammation which is situated in the cancellous cavities*, and thence spreads over the epiphysis, the periosteum, and a considerable part of the shaft of the bone.[1] If the affected bone be that of a limb possessing but one, in which case it is covered by a thick mass of muscles, the disease will owe its origin less to traumatic than to rheumatic causes; if, on the contrary, the bone be nearer to the surface, traumatic causes will predominate.[2] In our case of spontaneous separation of the epiphysis, the osteo-myelitis appears to have been produced by a fall upon the ice. Nevertheless, as I have already stated, I do not doubt that this disease may be produced by rheumatic causes.[3]

Preceded by inflammation of cancelli.

CASE L. *Amputation at the Hip-joint for Chronic Osteo-myelitis, following Gunshot Fracture of the Thigh; the Patient did well for some Time, but ultimately died, mainly from Renal and Pulmonary Disease.* — Dr. R. F. Weir presented to the New York Pathological Society, at the stated meeting, held June 28th, 1865, a femur which he had obtained from a discharged soldier, a patient of St. Luke's Hospital, by amputation at the hip-joint.

Dr. Weir's case.

This patient, Frederick Kelb, late Corporal Co. G., 7th N. Y. Vols., was wounded at the first battle of Fredericksburg, Dec. 14th, 1862, by two balls, which entered his right thigh; one of them, a minie, fractured the femur at the junction of its upper and middle thirds, and a number of large fragments of bone was said to have been extracted. The case progressed favorably, and he passed through several military hospitals, until he was discharged from the United States service, June 8, 1864. On the next day, June 9, 1864, he entered the St. Luke's Hospital at New York. The fracture had united, but there was evidence of bone disease. Subsequently a series of recurring abscesses formed in his thigh, which communicated with the seat of fracture, but no dead bone was felt. He kept about on crutches till October, 1864, when he was compelled by a repetition of the abscesses to go to bed. These abscesses all the time discharged more or less well-formed pus. In May, 1865, when Dr. Weir went on duty, a new abscess formed, running up towards the

[1] Dr. Klose perceived correctly the nature and pathological relations of the disease, although he named it *Separation of the Epiphysis*, or *Meningo-osteo-phlebitis*.

[2] Vide Barwell on *Diseases of the Joints*, p. 221 *et seq.*

[3] Vide *Causes of Osteo-myelitis*.

trochanter. The patient then commenced to fail rapidly; and it was believed that almost the entire femur was necrosed. A consultation was held, and it was decided to remove the thigh by disarticulation; which was accordingly done, by the method known as Prof. Van Buren's. Anæsthesia was produced with sulphuric ether, and the aorta was compressed with a clamp tourniquet. About six ounces of blood only were lost by the operation, and the shock was moderate. The patient was reported to be doing well.

The specimen was a very interesting and beautiful one of osteomyelitis. In the parenchyma of the head of the bone there were two small abscesses which had made their way nearly through the thin crusted surface. (The description as to other particulars is defective.)

Dr. Buck remarked that he thought the case was a very favorable one for the operation, and in fact, afforded an excellent illustration of the good effect of an operation performed for chronic disease of a limb.

The case progressed very favorably for some time. Three weeks after the operation, the healing of the stump was far advanced, and the patient was able to leave his bed. After this he began to lose ground very gradually. He died on October 4, 1865, nearly four months after the operation.

At the *autopsy*, the pelvis of the right kidney was found to be blocked up with numerous calculi; there was an abscess in the left kidney; and there was tuberculosis of both lungs at an advanced stage. The stump was still open, and the horizontal portion of the os pubis was necrosed.[1]

Comments. — Although this patient did not recover, still we think that the operation should, upon the whole, be considered as at least comparatively successful. He derived much benefit from it. The stump healed in great measure; he got able to leave his bed again in a short time, and lived for several months afterwards. When death occurred, it was mainly due to causes other than the operation. There was deep-seated constitutional disease, namely, pulmonary consumption, together with renal calculi and renal abscess. The patient's life was unquestionably prolonged for several months by the operation; and it is probable that recovery would have taken place, if the tuberculous dyscrasia had not been present.

Examination of the exarticulated femur showed that amputation in the continuity would not have proved successful in even a sound state of his constitution, because the head of the bone contained two small abscesses which were about ready to burst into the hip-joint. The removal of the limb by exarticulation was preferable to amputation in the continuity,

Amputation in continuity would not have saved him.

[1] The above account of this instructive case has been compiled from the *New York Medical Journal* for Dec., 1865, p. 195, and from *Circular* No. 7, pp. 41, 42.

because the latter operation would not remove all the diseased bone. No operation short of amputation at the hip-joint could have proved successful in this case; and in a patient of sound constitution similary affected, it could be performed with a reasonable hope of a successful issue. Indeed, it has been employed in several cases caused by the late War of the Rebellion, for the relief of chronic osteo-myelitis of the femur, with complete success.

Dr. Blackman's case.

Professor Blackman, of Cincinnati, amputated the limb of an ex-Confederate soldier, at the hip-joint, in consequence of chronic traumatic osteo-myelitis of the femur, January 18, 1866. The patient recovered, and was seen by Dr. B., seventeen months after the operation, in good general health. "An examination of the limb after its removal, showed that the entire shaft of the femur had been affected by osteo-myelitis."[1] The original injury was gunshot fracture of the femur.

Dr. Morton's case.

Dr. Thomas G. Morton, of Philadelphia, reamputated a thigh, at the hip-joint, for chronic osteo-myelitis of the stump-bone, with success, February 17th, 1865, at the Pennsylvania Hospital. The patient had already suffered secondary amputation of the thigh for gunshot injury, Nov. 14, 1864. This operation was followed by medullitis of the stump-bone. After the last operation the patient did well, and made an excellent recovery.

"The exarticulated portion of the femur presented a characteristic example of necrosis following chronic osteo-myelitis. A long loose sequestrum was found encased in a new deposit of porous bone, and was not limited to the diaphysis, but extended quite into the neck, and then projected through the ulcerated capsular ligament."[2]

It is also probable that in most of the other successful cases of secondary amputation or reamputation at the hip-joint, which are related in "Circular" No. 7, the lesion which rendered the operation necessary, was chronic osteo-myelitis of the femur. Besides the two cases just mentioned, there was one case of secondary amputation, and three cases of secondary reamputation, at the hip-joint, which were operated on during or since the late War of the Rebellion, and recovered.

Very acute osteo-myelitis.

Suppurative osteo-myelitis, in a very acute, that is, a diffuse form, when it occurs in the extremities, can but seldom be cured by any measure less thorough than the exarticu-

[1] See *Circular* No. 7, S. G. O, July 1st, 1867, p. 43.

[2] See *Circular* No. 7, pp. 51, 52; also *American Journal Medical Sciences*, July, 1866, p. 17 *et seq.*

lation of the diseased bone, or the amputation of the diseased part, performed in the sound tissues above it. The employment of either the one or the other of these operations is generally required in order to save the patient's life. Now, this treatment, to be effectual, must be adopted early, or, at least, before the case has become complicated with pyæmia. After that time it is useless to operate, for life is neither saved nor prolonged by it, except in those instances where profuse parenchymatous hemorrhage, uncontrollable by means other than amputation, is present as an additional complication. But acute suppurative osteo-myelitis often produces pyæmia in a few days, or in a very brief period of time. The operations for its relief, when the necessity for their performance has once been perceived, cannot therefore with propriety be deferred. Exarticulation, however, has sometimes proved successful, even after the appearance of pyæmoid symptoms. This happened in Case XX., and in another instance related to me by a professional friend. Both of them were exarticulations of the shoulder. No operation, whether amputation or exarticulation, has ever been known to be successful after true pyæmia, or the disease which we understand to be, and have elsewhere described as such, has made its appearance; at least, I have never seen, nor heard, nor read of a case of that sort. The chances of the patient's recovery are also decidedly less if pyæmoid symptoms are present; and, generally, the earlier the operation can be performed after its necessity is recognized, the greater is the likelihood, other things being equal, of the patient's recovery.

Amputation never successful when pyæmia exists.

Prof. Fayrer, of Calcutta, however, has reamputated the thigh, at the hip-joint, in two cases of diffuse osteo-myelitis of the stump-bone, after pyæmic symptoms had distinctly appeared, and succeeded in saving one of them. The first case occurred in 1864, in the person of a lad, aged 16, and the exarticulation resulted favorably. The last case occurred in 1867, in a patient aged 21. The thigh was amputated on July 2, for traumatic inflammation of the knee-joint. On the 4th, the stump was exarticulated, at the hip, for diffuse osteo-myelitis; but death occurred thirty-eight hours afterwards, from cardiac embolism (thrombosis of the heart). The medulla of the stump-bone was found to be infiltrated with pus.[1]

The following example of osteo-myelitis is related here, because of its interesting, although exceptional character. It followed a

[1] See *Medical Times and Gazette*, Nov. 9th, 1867, pp. 483, 484; also Dr. Packard's Paper in *New York Medical Journal*, vol. ii. p. 163.

white swelling of the knee, and simulated the white swelling after that disease had for the most part disappeared. It was exceedingly chronic, and had a scrofulous origin. It reappeared in the stump-bone, after amputation of the thigh, and became again apparently as severe as ever. The case is unique, interesting, and instructive, in respect to both the white swelling, and the inflammation of the medullary tissue. The examination of the amputated member showed that the disease of the knee-joint was in the process of recovery, and that the cure appeared to be rapidly approaching completion. The distress and other local symptoms which the patient suffered, must therefore be referred, almost entirely, to the inflamed condition of the marrow.

CASE LI. *Scrofulous Osteo-myelitis of the Femur, very chronic in Character and following White Swelling of the Knee; Amputation of the Thigh; the Stump closed well, but the Disease reappeared in it; Resection of about one Inch of the Stump-bone.* — An unmarried lady, aged about 28, of strumous diathesis, had been afflicted for four years with white swelling of the left knee, and during the last year was bed-ridden. Before the last mentioned period, on keeping still for a while and taking treatment, the disease would subside, and she would get apparently well, but it always returned again in five or six weeks after she began to go about. The resources of the surgical art had been exhausted without effecting her cure. She had taken constitutional treatment, and her diseased joint had been treated by extension, blisters, nitric acid issues, and the actual cautery. At the commencement of December, 1865, her condition was as follows: the knee was swollen to about twice its natural size, and contracted to about a right angle; it was also warmer than natural, and reddened and scarred from the surgical treatment it had received; the leg and foot were swollen and œdematous; she complained much of an aching pain in the knee, which was more severe at night, and accompanied by twitchings and startings of the limb; she was restless, and her sleep was disturbed on account of the pain. She was moderately anæmic and feeble in strength. The local swelling and heat were prominent symptoms.

Dr. Gouley's case.

On the 9th of December, Dr. J. W. S. Gouley amputated her thigh for the purpose of procuring relief from suffering, all other means having failed. The patient took ether as an anæsthetic, and the operation was performed by the lateral flap method. She bore the operation well. The greater part of the stump united by adhesion. She made a good recovery, and went into the country.

Examination of the Amputated Member. It was found that the swelling of the knee was produced almost entirely by thickening of the periarticular tissues. There was but a small quantity of liquid in the knee-joint.

The cartilage of incrustation was thinned, softened, and considerably eroded, and in spots new, red granulation tissue projected through it into the cavity of the joint.[1] The medullary tissue of the parts of the femur, tibia, and patella, examined, especially the first named, was inflamed and hepatized.[2] The compact tissue was thinner and less dense than natural. Its medullary spaces were enlarged. The articular lamella of the femur was considerably thinner than natural. It was readily incised with a scalpel. The osseous septa or partitions between the cancelli, were also considerably thinner and softer than natural, and the spongy structure of the femoral condyles was easily cut with a scalpel. The periosteum was redder and thicker than natural.

Microscopical Examination. — The thinned, eroded, and softened cartilage of incrustation was found to consist of various-sized cartilage corpuscles which were granular, and connective tissue, the fibres whereof were mostly wavy; a few of them, however, were curling. Granular cartilage cells were seen in the midst of the connective tissue which had been formed for the purpose of replacing the diseased cartilage, and ultimately inducing, perhaps, anchylosis of the joint.

The hepatized marrow consisted of an abundant quantity of free granular marrow cells, some fat vesicles, a little connective tissue, and capillary blood-vessels.

On making a thin transverse section of the compact tissue of the femur with a saw, and examining it with a hand-glass, the Haversian canals were seen to be enormously enlarged (commencing osteo-porosis).

The patient was relieved from her sufferings for a time, but the bone-pain ultimately returned in the stump, in a severe form. On the 9th of March Dr. Gouley attempted to cure it by opening the stump, and cutting off a piece of the bone about an inch long, with a chain saw. The stump did well after this operation, but the pain was not relieved. Examination of the resected portion showed it to be affected with chronic osteo-myelitis.

March 23. I had an opportunity to examine the patient through the politeness of Dr. Gouley. The wound of the last operation was not yet entirely healed, but it was granulating finely. There was a strong tendency on the part of the granulations to become converted into osseous tissue. She complained a good deal of aching pain in the bone, which was worse at night, and said that the stump sometimes jumped. She was somewhat anæmic, but in fair flesh. She was taking the iodide of potassium. It was decided to increase the doses of that medicine, and to paint the stump with tinct. iodine.

Under this treatment she slowly improved, and, after some months, recovered so far that her general health became tolerably good.

Comments. — In this case the inflammatory irritation produced a

[1] Vide Plate XII. [2] Vide Plate XII.

remarkable effect upon the osseous tissue. It caused a rarefaction of the compact tissue of the femur by increasing the size of its Haversian canals and Haversian spaces, and a rarefaction of its cancellous structure by diminishing the number and thickness of the osseous partitions which separate the cancelli. In this way the bone became decidedly more porous than natural, and a condition was induced, to which the term *osteo-porosis* has been applied. In this case the porosity of the condyles of the femur was so much increased, the septa between the cancelli and ever the articular lamella were so much thinned, that the osseous tissue into the formation of which they enter, was easily cut with a scalpel. This kind of rarefaction of the osseous tissue appears to be produced in the following way: the inflammatory irritation spreads from the medullary tissue contained in the cancelli and the larger Haversian canals, and involves the osseous laminæ which lie in contact with it, producing in those laminæ softening of the intercellular substance with disappearance of the calcareous salts, and a conversion of the bone-corpuscles into marrow cells, or, in other words, a transformation of certain osseous laminæ into medullary tissue. The effect of this kind of transformation of the osseous tissue is, to destroy some of the osseous partitions between the cancelli, to diminish the thickness of all that are subjected to this peculiar process, and thus to increase the size of the cancelli, and in consequence render the bone more porous than natural. In a similar way this process of transformation increases the size of the Haversian canals and spaces in the compact tissue, and produces an abnormal porosity of it.

Osteo-porosis.

Operative Medication especially required by the Chronic Forms of Osteo-myelitis. — The general and topical medication required in treating chronic inflammation of the medullary tissue has already been discussed at sufficient length. It is therefore necessary now to say only a few words upon the surgical operations which may be required in the course of the treatment of the chronic forms of this disease. It has already been stated that chronic osteo-myelitis frequently produces necrosis. Now, the surgical operation which the professional man is called on to perform much more frequently than any other for the relief of this variety of the disease, especially when it invades the stumps of amputated limbs and the parts involved in compound fracture, is the extraction of the necrosed bone as soon as it has become completely detached. If the dead bone is found to be imprisoned within an

Operative procedures.

osseous case formed by the development of new bone (involucrum), the surgeon should liberate it, by making suitable incisions in the soft parts and a sufficient opening in the bony case, with the aid of the trephine, together with the mallet and the chisel. This operation has proved remarkably successful. The specimens derived from this category, which, together with the histories of the respective cases, have been collected in the Army Medical Museum at Washington, are very numerous, and show that this operative proceeding has almost always eventuated in the recovery of the patient. In some instances, however, exarticulation of the diseased member has been necessary.[1] But this operation has not been often demanded in the treatment of the cases of chronic osteo-myelitis which were seen in our military hospitals during the late war; not nearly so frequently as one would be apt to suppose after reading the memoir of Dr. Jules Roux upon the chronic forms of osteo-myelitis which he saw in the St. Mandrier Hospital, at Toulon, in 1859, among the wounded brought back to France from the Italian campaign of that year. M. Roux found it necessary to exarticulate the diseased member in twenty-two cases, among about two thousand wounded, and of these exarticulations four were at the hip. But in our military hospitals during the late war, the comparatively trifling operation of extracting the necrosed bone as soon as it became completely separated from the living bone, was generally sufficient to effect a cure. Sometimes, however, it was found to be necessary to exarticulate the diseased bone, and perhaps in occasional instances that operation was not employed when it should have been. With regard to the employment of the operation of amputation performed in the continuity of the limb for the cure of chronic osteo-myelitis, I am thoroughly convinced that, if the ablation of the diseased member is rendered necessary on account of the ravages occasioned by inflammation of the medullary tissue, it is much better and safer for the patient to remove the limb at the articulation than to amputate in the continuity. The reasons upon which this conviction is founded, have, for the most part, been already expressed.

Chronic osteo-myelitis, when it produces chronic abscess of the medullary tissue, requires for its cure, as already stated in another place, that it should be laid freely open by trephining its osseous walls, etc., and that during the after-treatment it should be dressed daily from the bottom with dry lint for the purpose of making it heal up soundly.

[1] Vide Case L.

Stump-bones, which are much enlarged at their sawn extremity in consequence of chronic osteo-myelitis, and perhaps also protrude somewhat on that account, generally require to be resected; or, in other words, it is necessary in such cases, for the most part, to excise the surplus portion of the bone. Unless this is done, the stump remains ulcerated, irritable, painful, and is not only unfit for any useful purpose, but also becomes a source of much discomfort to the patient. Such an operation is readily performed by opening the stump freely by incision, and, after detaching the soft parts from the bone to sufficient extent, cutting off the surplus part of the bone with a chain-saw or with a cutting forceps. This operation, in general, should not be attempted until the disease has lasted for a considerable time, and the morbid process has become quite indolent and chronic. If it is performed too early, it may aggravate the malady in the rest of the bone, and induce a state of acute inflammation therein, a result which I once saw occur in a case of this sort. This patient's life was in great jeopardy for many days, but he ultimately got entirely well. The operation is seldom followed by trouble or danger after the disease has reached the indolent stage.

CHAPTER SECOND.

OF PERIOSTITIS.

Anatomical Structure of Periosteum. — Less Vascular than the Medullary Tissue. — Peculiarly liable to Traumatic Injury. — Frequency of Ecchymosis and its Cause. — Traumatic Inflammation of the Periosteum generally a Reparative Process. — Occasionally it proceeds to Suppuration, forming, in most Cases, Circumscribed Sub-periosteal Abscesses. — Primary Traumatic Periostitis seldom fatal, nor does it often occasion Extensive Necrosis. — Removal of the Periosteum does not always cause Superficial or Lamellated Exfoliation of Bone. — In Gunshot Injuries of Bone, Punctiform Ecchymoses are often found at Points remote from the Seat of the Principal Injury. — Three other Varieties of Periostitis, namely, Scrofulous, Syphilitic, and Rheumatic, neither of which are described at length by the Author. — Symptoms of the Primary Traumatic Periostitis. — Secondary Traumatic Periostitis often a Sequence upon Osteo-myelitis. — Occasionally Inflammation occurs simultaneously in the Periosteum, Bone, and Medullary Tissue. — Acute Periosteal Abscess. — Its Infrequency, its Liability to be mistaken for Osteo-myelitis. — Most frequent about the Age of Puberty, and manifests other Preferences relating to Sex, etc. — Causes Extensive Necrosis. — Seventeen Conclusions relating to the Malady deduced by Chassaignac, including the Diagnosis and Treatment. — Additional Remarks by the Author.

THE *periosteum* is a membranous structure or sheath which directly invests the exterior of the bones through their whole extent, with the exception of their articular cartilage, and the tendinous insertions of certain muscles. When healthy, it has generally a yellowish-white color. In some situations, however, it presents a white and glistening appearance. It consists, for the most part, of a very dense connective tissue, which contains an extremely large quantity of elastic fibres, and in which the blood-vessels ramify, before they pass on into the cortex of the bone itself. But, in respect to vascularity, that of the periosteum is very much less than that of the medullary tissue; and, from the large quantity and peculiar character of the fibres of connective tissue which it contains, it is dense, strong, and elastic. In the natural state it is also firmly adherent to the circumferential laminæ of the bones in contract with which it is placed.

Less vascular than medullary tissue.

The periosteum, from lying in immediate relation with the comparatively solid and unyielding osseous tissue, is exceedingly apt to suffer injury from violent causes. It is liable to be bruised by the external application of force in the nature of contusion (contusing force), and is then found to present an ecchymosed appearance, occasioned by the extravasation of blood from ruptured capillary

vessels. Ecchymosis of the periosteum is not unfrequently produced by the stroke of gunshot projectiles, by the kicks of horses and mules, and by violent blows of any kind inflicted over a bone, especially if it be but thinly covered with soft tissues. The periosteum is also liable to suffer solutions in its continuity from gunshot wounds, incised wounds, and osseous fracture. In connection with contused and lacerated wounds of the periosteum, there is almost always considerable ecchymosis, and occasionally the space occupied by the extravasations of blood is very large. We have always found more or less ecchymosis of the periosteum in connection with fractures and gunshot wounds involving bone. Not unfrequently the ecchymosed appearance of this membrane extends to a considerable distance from the immediate seat of the injury, especially in cases where the long bones are wounded by gunshot projectiles, and seems to be produced in the following way. The osseous tissue when struck by a musket-ball, for example, is thrown into vibrations, and, at the same time, the periosteum and the medullary tissue are also thrown into vibrations along with the bone. But, from the difference in respect to density and elasticity between the periosteum and the bone, it results that their respective vibrations are not rhythmical, and the discordance may be so great as to rupture the capillary blood-vessels of the periosteum.[1] The distance to which ecchymosis of that membrane produced in this way may extend, will depend largely upon the degree of the force which produces the vibrations. In some cases it has been found to embrace almost the whole extent of the diaphysis of a long bone.

Ecchymosis. How caused.

Now, growing out of this ecchymosis of the periosteum, and of the violence which has produced it, there is almost always more or less inflammatory irritation of this membrane; and, not unfrequently, this irritation becomes so intense as to induce the inflammatory process, and develop a true *periostitis of a traumatic character*.

Traumatic inflammation of the periosteum is generally a reparative process, and terminates in the formation of new osseous tissue, which in turn may disappear soon after the subsidence of the inflammatory irritation, provided the new osseous formation is not essential to the well-being of the or-

Generally a reparative process.

[1] On this point Pirogoff remarks, "That which Neudörfer has said concerning the effects of a projectile upon the periosteum, I find very characteristic and agreeing with my own convictions. 'An elastic bone struck by a projectile is thrown into vibrations of a certain extent and duration, like a tense cord or spring. . . . . If the bone vibrates too rapidly, so that the periosteum and other soft parts cannot follow these vibrations or movements, the membrane becomes detached from the bone.'"

ganism. In the stumps of amputated limbs we have not unfrequently seen the periosteum much thickened and reddened, *i. e.* inflamed, and detached from the end of the stump-bone upwards to the distance of several lines. In such cases there is usually annular necrosis, and the consequence is that after the ring of dead bone has been exfoliated, a new osseous growth developed from the proliferating layer of the inflamed periosteum, assists in repairing the loss of bony substance occasioned by the necrosis.[1]

Occasionally suppurative, but seldom diffuse.

Occasionally, however, *traumatic periostitis* proceeds to the formation of purulent matter. In such cases the suppurative inflammation of the periosteum, for the most part, occupies but a limited space, and the purulent collection is formed between it and the bone, or, in other words, a circumscribed periosteal abscess is produced. In very rare instances, it has been related of traumatic periostitis, that it was diffuse in character, and accompanied also by diffuse suppuration; but such an instance I did not meet with during the late war, and I have neither heard nor read of such a case occurring in our army during that period, although I have made diligent inquiry to that end. Of course primary inflammation of the periosteum alone is here referred to. One of the most striking differences which I have noticed between the clinical history of *traumatic osteo-myelitis* and that of *traumatic periostitis*, is, that while the former exhibits a strong tendency to run into the stage of suppuration, the latter seldom produces such a result, and that while the former frequently destroys the life of its victim, the latter almost never proves fatal. During the whole period of the late war, among several thousand wounded who came under my own observation, I did not even see one fatal case of primary inflammation of the periosteum; and I can go further, and declare that during all that time I did not even meet with one instance of primary periostitis produced by any cause whatever that proved to be troublesome in its management. But,

[1] Periostitis gives rise to new bony growths, because the deep or osteogenetic layer of the periosteum is excited to abnormal activity. The new cell growths become bone-corpuscles, and the new intercellular substance calcified osteine. The process consists of direct transformation of preëxisting structures. "There is no mysterious organization of a previously exuded juice, no development of blastema or of exudation corpuscles, no transformations of blood-clots or of supposititious lymph. There is no new process brought into action; nothing but a *traumatic excitation of the ordinary bone-producing functions of the periosteum.*" See Ollier in *American Journal Medical Sciences*, January, 1868, p. 153. In the cases belonging to the category which we are now considering, the excitation of the osteogenetic or proliferating layer of the periosteum is inflammatory in its nature. When raised beyond a certain point, the product of the proliferation becomes, not new osseous tissue, but purulent matter, and thus an abscess may form in connection with bone.

during the same period, primary osteo-myelitis of a traumatic origin was a disease which frequently came to my notice, and was very often seen to produce a fatal result; indeed, it was one of the most frequent of all the causes of death occurring from gunshot wounds involving bone, or from surgical operations undertaken for the relief of this kind of injury. Again, while during the last four months (prior to the time of this writing, March 25, 1866), I have met with ten cases of osteo-myelitis occurring in civil practice, nine of which belonged to the acute and one to the chronic variety of this disease, six of which died, and the remaining four were saved by the performance of surgical operations (*e. g.*, amputation in two instances), I have not seen a single instance of primary periostitis that proved dangerous to life. From these facts I have been led to believe that while primary periostitis is a disease of importance, and should not be overlooked, primary osteo-myelitis is a disease of much greater importance, and much more destructive to human life; that the one is, for the most part, troublesome because it is inconvenient to bear, and the other because of its fatal character.

When the periosteum is inflamed, its color becomes reddened, and its thickness increased. At the same time the tenacity with which it adheres to the bone itself is diminished. If the inflammatory process in it proceeds to the formation of pus, the purulent matter is collected between it and the bone. In such cases necrosis of at least the denuded circumferential laminæ is very apt to occur, and the dead bone is ultimately disposed of by laminated exfoliation.[1] Extensive necrosis, however, as a result of the detachment of the periosteum from primary inflammation of this membrane alone, occurs but very rarely, according to my observations.

Laminated exfoliation is apt to occur.

The following case affords a good example of the character of the exfoliation of dead bone which pertains to traumatic primary periostitis.

Case LII. *Gunshot Wound of Left Thigh; the Bullet grazed the Femur without fracturing it; Suppuration continued over Three Years, with Occasional Discharge of Scales of Bone (Exfoliations);* contributed by H. M. Lyman, M. D., of Chicago, Ill. — Isaac D. Page, Co. K, 57th Ill.

[1] I have, however, seen a considerable number of cases wherein the bone was extensively denuded of periosteum, that were not followed by the exfoliation of any dead osseous tissue whatever. The bones in which I have seen this occur, were those of the cranium, the face, the thigh, and the leg. On the same point Mr. Holmes says, "It is true that large separations, and even extensive destruction, of the periosteum may occur without the death of any portion of the bone." *System of Surgery*, vol. iii. p. 641. London, 1862.

Vols., aged 24, was wounded at the battle of Shiloh, Tenn., April 5, 1862, by a rifle-ball which entered his left thigh three inches above the articulation of the knee, and, passing horizontally from left to right under the quadriceps extensor cruris muscle, grazed the anterior surface of the bone, and emerged upon the inner surface of the thigh. Patient was treated in the U. S. Hospital at Evansville, Ind., where he remained five months. During the first five weeks he was confined to his bed, the limb being kept constantly extended. This treatment resulted in cicatrization of the wound, and complete anchylosis of the knee. Was retained in hospital for five months, and then discharged from the service. Every few weeks an abscess forms about the place of injury, and on being opened, whether spontaneously or otherwise, discharges for a few days, sometimes giving an outlet to small scales of bone.

Present Condition, July 15, 1865. — An abscess has just been opened close to the original cicatrix upon the inner face of the limb. There is complete anchylosis of the knee, and the patella is adherent.

A probe reached carious bone, but no loose necrosed fragments were discoverable. There is no shortening, and he is able to use the limb, when the abscesses are closed.

Concerning gunshot lesions of the periosteum and their consequences, Pirogoff says: —

"Whenever a bone injured by a projectile is carefully examined, the following changes, which I consider of the utmost importance, are found in the periosteum and medullary cavity.

"The periosteum is found either exposed and suggillated (ecchymosed) or detached to a greater or less extent from the bones and soft parts as well as suggillated. *The extravasated blood is either limited to one spot or disseminated.* I have not unfrequently observed, after amputations performed at a considerable distance from the injured point, small punctiform periosteal extravasations. It may, therefore, with great probability, be assumed that the *concussion in comminuted gunshot fractures is propagated through the entire diaphysis to its place of junction with the epiphysis, detaching the periosteum at some points to a greater, at others to a less extent, and rupturing the small connecting and anastomosing vessels.* By these changes, and by similar ones in the medullary tissue, may be explained the extensive necrosis occurring so frequently after amputation, and also the not unfrequent *osteomyelitis.*

Effects of concussion upon periosteum. Pirogoff.

"The true (proper) *sac-like sub-periosteal extravasation* is found in the cranium, only now and then, after glancing blows from projectiles. In the long bones it is exceedingly rare; I have only met with it after severe contusion of the tibia. Under other circumstances, periosteal extravasations are, for the most part, either diffused or punctiform. If the bone be crushed, the periosteum in the vicinity of the fracture is not

unfrequently found detached like a flap, and separated from the bone and soft parts by extravasated blood. Ichorous suppuration of the sub-periosteal extravasation, secondary detachment of the periosteum by suppuration, exposure of bone, necrosis, and osteophytic formations, are almost inevitable consequences of this traumatic concussion of the periosteum. Whoever has had much to do with the conservative treatment of gunshot fractures of the upper extremity, and has often had occasion to perform secondary resection in these cases, knows how far the purulent accumulations may reach under the periosteum, and to what distance the osteophytic formations may extend. But also in instances where there has been no injury of bone, there sometimes occurs after long suppurating wounds near bone, particularly in the vicinity of an epiphysis, this phenomenon in so marked a degree that the idea readily suggests itself that an unrecognized fracture may have existed. Beyond doubt the unexpected osteophytic formations taking place under such circumstances must be ascribed to concussion, local detachment of the periosteum, and to scattered extravasations underneath it. It is but seldom after slight glancing blows from spent balls that clearly defined periosteal contusions are met with, such, for example, as occurred in the case mentioned by Stromeyer. (A shot struck the os calcis on its outer side, without perforating the boot. After a short time a tumor was felt at the injured point very similar in shape to the half of a musket-ball.) In examining amputated limbs in cases where the periosteum presented punctiform suggillations, though still adherent to the bone, it has appeared to me to admit of being detached with more ease from the entire shaft than in the normal condition. Examination of limbs removed in the *intermediate* period, very frequently discloses suppuration of the sub-periosteal extravasations, and a serous and sero-purulent infiltration of the periosteum. It is probable that the acute purulent œdema of the deep cellular planes, which sometimes follows severe injury of bone, is the direct consequence of these lesions of the periosteum."

But these periosteal lesions are almost always accompanied with corresponding lesions of the marrow. Moreover, in such cases the medullary tissue usually presents the inflammatory process at a stage much further advanced in the work of destruction, than the periosteum. In such cases the medullitis almost invariably proves to be more destructive to tissue and dangerous to life than the periostitis. In such cases the medullitis generally becomes in reality the chief, and the periostitis the subordinate affection ; and secondary ostitis with necrosis occurs more in consequence of the former than the latter disorder.

Ollier, in treating of the inflammatory changes which are produced by traumatic irritation of the different structures which enter into the composition of bone, remarks, that the rapidity with

which these changes occurs varies very much according to the tissue affected. In the deep (osteogenetic) layer of the periosteum, and in the marrow, where the intercellular (basis) substance is loose and unresisting, these modifications take place more quickly and readily than in the fibrous and cartilaginous structures where the intercellular substance is more dense. The process is still slower in the osseous structure proper, and is almost totally inappreciable in the completely formed adult bone.[1] The inference is unavoidable that inasmuch as the marrow is the softest and the richest in cells of the several structures which enter into the composition of bone, even so it is more liable than the others to suffer from traumatic causes, to experience inflammatory changes, and to become transformed into pus.

Besides *primary periostitis of a traumatic origin*, *three* other varieties of this disease are recognized. They are, first, the *scrofulous*, second, the *syphilitic*, and, third, the *rheumatic* form.

The symptoms ordinarily produced by primary inflammation of the periosteum are pain referred to the seat of the disease, and more severe at night; tumefaction of the periosteum itself, which can generally be detected by manual examination, unless the inflamed membrane is deeply covered by soft parts, as in the thigh, etc., and tenderness under pressure. If the seat of the inflammation be circumscribed or limited, the swelling is commonly called a node.

It is not proposed to discuss the *scrofulous*, the *syphilitic*, and the *rheumatic* varieties of periostitis at length in this place, because, in the first place, the experience of the late war does not appear to have developed any new facts in their clinical history; and, in the second place, the treatises on surgery in general use contain tolerably full accounts of them, especially their symptomatology and therapeutics.

Secondary periostitis.

The form of periosteal inflammation which thus far has claimed our attention is the *primary*. A few words should also be said upon the *secondary* forms of this disease. We have already seen, while studying the subject of osteo-myelitis, that, not unfrequently, the inflammatory process commencing in the medullary tissue extends through the bone to the periosteum, at a later period, and produces in it a series of histological transformations which were then pointed out at considerable length.

[1] See *American Journal Medical Sciences*, January, 1868, p. 150.

The periosteum also becomes inflamed in a secondary manner, sometimes, by the extension of the inflammatory process to it from the surrounding soft parts.

Occasionally a case is met with in which the inflammatory process in an acute form has been lighted up simultaneously in the periosteum, the marrow, and the osseous tissue itself, constituting a veritable inflammation of the bone in totality. In such cases the progress of the disease is generally very rapid, the local pain and the constitutional disturbance are very great, necrosis involving the whole thickness of the diseased bone is quickly produced, and extensive suppuration within the medullary tube, likewise in the space between the detached periosteum and the bone, and sometimes in the surrounding soft parts, takes place. Such a coexistent inflammation of the periosteum, the bone, and the marrow, in an acute form, is one of the most rapidly destructive of all the diseases with which man is afflicted.

The Acute Periosteal Abscess. — We have already stated that diffuse inflammation of the periosteum is not a disease of frequent occurrence. The acute periosteal abscess which must be considered as one of the consequences of diffuse periostitis, occurs still more rarely than that disease. On account of its occasional connection with, but more especially its liability to simulate osteo-myelitis, this form of abscess claims some attention at our hands in this place. It is preëminently a disease of youth, and occurs most frequently about the age of puberty. Of twenty-three cases collected by Chassaignac, four occurred prior to the age of ten years, fifteen between ten and eighteen, and four between eighteen and thirty-six.[1] It attacks males more frequently than females. It invades the lower more often than the upper extremity. The strumous dyscrasia and debilitated conditions of the body arising from insufficient food, unwholesome dwellings, and overwork, appear to be predisposing causes for its development. In the acute periosteal abscess the purulent collection and the swelling produced by it are usually spread over a large surface. It is very apt to produce extensive necrosis and to put the patient's life in great jeopardy. It is not unfrequently accompanied by acute suppurative osteo-myelitis together with inflammation of the osseous tissue itself. Chassaignac relates a case of that sort, wherein the disease was produced by violence.[2] But this disease may occur

Acute periosteal abscess.

[1] Vide *Traité Pratique de la Suppuration*, t. i. p. 413. [2] *Op. cit.* t. i. pp. 436, 437.

without being complicated with suppurative inflammation of the medullary tissue.[1] Two cases of acute periosteal abscess have been observed by the author. Both were children under ten years, of the male sex, and of a decidedly scrofulous diathesis. In both the tibia was the seat of the disease. After long treatment both recovered with useful limbs. Anti-scrofulous medication proved very beneficial. Chassaignac, who has investigated this disorder with a good deal of care, and written the best account of it which we possess, has stated seventeen conclusions which he had been led to adopt concerning it. They are as follows: — Chassaignac's conclusions.

1. The period of youth and the scrofulous dyscrasia constitute a notable predisposition to the acute periosteal abscess.

2. The lower extremities are especially predisposed to this kind of abscess.

3. Among the causes of this disease there ought to be mentioned: 1, rheumatic parentage; 2, humid dwellings; 3, external blows; 4, strong mental commotion; 5, fatigue, when excessive and disproportionate to the age of the subject; 6, the critical epoch of the eruptive fevers; 7, the sudden suppression of suppuration in the fistulous channels kept up by diseased bone.

4. In acute periosteal abscess the pain precedes all the other symptoms, even the fever; this pain is excessive, deep-seated, and analogous to that of severe whitlow. It gives to the patient the sensation of impending fracture; it is subject to nocturnal exacerbations.

5. This disease is not accompanied by any alteration in the color of the skin.

6. In acute periosteal abscess of the femur the disease commences almost always in the inferior half of the bone.

7. In this disorder the tumor fluctuates, but coalesces with the bone.

8. The means of perceiving fluctuation in acute periosteal abscess of the thigh, consists of grasping the member with both hands and practicing upon it pressure alternately in opposite directions.

9. The pus of this kind of abscess presents oil globules.

10. In acute periosteal abscess, there is always necrosis, more or less superficial, of the bone upon which the abscess rests; the sequestrum which results from it may disappear, either by resorption, or by elimination in small fragments.

11. In acute periosteal abscess, whatever its extent may be, the articulations contiguous to the affected bone almost always preserve their integrity, while in osteo-myelitis they are generally affected.

12. The acute periosteal abscess is distinguished clinically from the

[1] Vide *Traité Pratique de la Suppuration*, t. i. p. 437 *et seq.*, Case 148.

diffuse phlegmon (cellulitis): 1, by the absence of puffiness; 2, by the presence of distinctly circumscribed fluctuation; 3, by the localization of the swelling upon one bone in particular, as compared with the diffused tumefaction of cellulitis; 4, finally, by the peculiar character of the pain.

13. The first indication to fulfill in the treatment of this disease is to cut promptly and freely down to the bottom of the abscess.

14. Some cases of acute periosteal abscess require the employment of counter openings.

15. In the treatment of acute periosteal abscess, the antiseptic washes, the drainage tubes, and the perforated seton, are useful auxiliaries against putridity; the douches with muriatic acid, in the proportion of from one to two parts to a thousand, hasten the disappearance of the sequestra.

16. The acute periosteal abscess may require to be treated either by primary amputation, on account of the considerable disturbance which it produces, or by secondary amputation, when it becomes a cause of constitutional exhaustion.

17. The employment of the preparations of mercury is contra-indicated in the treatment of periosteal abscess, especially when it occurs in young and scrofulous subjects.[1]

We have already pointed out the method of distinguishing suppurative inflammation of the medullary tissue from acute periosteal abscess.[2]

The employment of free incisions, the administration of anodynes to allay pain, and a nourishing diet to support the patient's strength, constitute no inconsiderable portion of the treatment appropriate for acute periosteal abscess. Cod-liver oil, iron, and quinine also are generally useful, especially in treating the scrofulous forms of the disease.

According to my own observations, suppurative inflammation of the marrow is a disease of much more frequent occurrence than diffuse inflammation of the periosteum of a suppurative character.

In respect to *treatment*, *traumatic periostitis* (primary) but seldom requires particular attention. Generally, the remedial measures which suffice to cure the injury sustained by the investing soft parts, suffice also for the relief of the inflamed periosteum.

[1] Vide *Traité Pratique de la Suppuration*, t. i. pp. 438, 439.

[2] See Diagnosis of Osteo-myelitis.

These measures consist of cold applications, such, for example, as the cold-water dressing, and, in severe cases, the ice-dressing, quietude, and the local abstraction of blood in occasional instances. When the acute stage has been passed, the tincture of iodine may oftentimes be applied to the affected part with benefit. Occasionally, however, purulent collections are established between the periosteum and the bone in consequence of injury. These should be freely incised at an early period, indeed, the earlier the better after the formation of matter has occurred; and when necrosis results from them, the dead bone should be extracted as soon as it exfoliates. When inflammation of the medullary tissue exists at the same time or is coincident with the periostitis, it requires the adoption of remedial measures calculated to lessen its intensity and to obviate its consequences, which have already been discussed at sufficient length.

CHAPTER THIRD.

OF OSTITIS.

Infrequency of Acute Primary Ostitis, and the Reasons therefor. — Varieties of Ostitis, namely, Traumatic, Scrofulous, Syphilitic, Rheumatic, and Gouty. — Traumatic alone discussed. — Chronic Traumatic Ostitis not infrequent as a Secondary Affection. — Pathological Changes. — Redness and Sclerosis, or Induration, are the Primary Changes. — Observations of Mr. Barwell. — Subsequently the Bone becomes lighter and more porous (Osteo-porosis) in Consequence of Interstitial Medullizations. — Sclerosis and Osteo-porosis sometimes coexist in Different Portions of the same Bone. — Ostitis proceeding to Suppuration, and forming sometimes Chronic Abscesses of Bone, with other Pathological Changes resembling those which occur in Abscess of the Soft Parts. — Symptomatology. — Wet or Mephitic Gangrene of Bone may occur as a Result of Ostitis. — Treatment, general and local, in the Acute and Chronic Forms. — Treatment of Chronic Abscess of Bone.

Primary inflammation of the osseous tissue, in an acute form, by which is meant an acute inflammation commencing in the bone-corpuscles and the calcified intercellular substance of the osseous tissue proper, is a disease which is but rarely met with; while acute medullitis and periostitis, but especially the former, not unfrequently present themselves as primary disorders (as we have already seen), resulting from injury. Nor are we surprised at this comparative rarity of acute primary ostitis, when we remember how vascular and rich in cell-structures the medullary tissue is; while the osseous tissue proper is among the least vascular of all the tissues of the body, and at the same time is but scantily supplied with corpuscular elements. Acute inflammation, located primarily in the osseous tissue, is generally soon attended with inflammation of the periosteum and the marrow, because the inflammatory process quickly spreads to those structures from its starting-point in the bone tissue. In such cases the inflammation of the marrow or the periosteum is truly a secondary affection, that is, it has been induced by a preëxisting inflammatory lesion of the bone structure proper. But acute ostitis very seldom stands in this relation to either medullitis or periostitis. Acute secondary ostitis, however, not unfrequently occurs.[1]

Acute primary ostitis rare.

[1] According to Ollier, "inflammation does not affect the bone-cells proper, except secondarily; its first effects are produced upon the marrow cells, the osteogenetic layer of the periosteum, and the contents of the Haversian canals." (See *American Journal Medical Sciences*, January, 1868, p. 152.)

The causes of ostitis are manifold; and hence we recognize several varieties of this disease. We admit, 1st, the *traumatic*, 2d, the *scrofulous*, 3d, the *syphilitic*, 4th, the *rheumatic*, and 5th, the *gouty* forms of inflammation of the osseous tissue. We shall restrict our attention mainly to the first named, that is, traumatic ostitis, in what we are about to say upon the subject of ostitis, because there is not sufficient space at our disposal to permit us to enter into an extended consideration of the other forms of this malady.

While acute primary ostitis occurs very rarely from any cause, chronic inflammation of the osseous tissue not unfreqently presents itself as a primary affection; especially the scrofulous, the syphilitic, and the rheumatic varieties of it. Chronic ostitis of a traumatic origin is also frequently seen, but it is generally *secondary* in character; that is, the inflammatory process has commenced in a neighboring tissue, such as the marrow or the periosteum, and spread from it to the osseous tissue proper. Cases X., XI., XXIX., XLIV., XLVIII., LI., etc., afford examples of such an occurrence. Now, while traumatic ostitis of a *secondary* character is frequently seen, traumatic ostitis of a *primary* character is but seldom encountered, because the elementary structure of bone tissue is such that it is much less liable than the marrow and the periosteum to become irritated by mechanical causes. Such causes operating upon bone as a whole thus generally produce inflammation in the marrow or the periosteum before the bone-tissue becomes involved.

Chronic secondary traumatic ostitis more common.

Primary traumatic ostitis rare.

The following case affords the only example of *primary* traumatic ostitis that came under my observation during the late war. It is possessed of much interest in other respects besides the disease of the bone, and therefore it is related at length. The patient at one time fell into an apparently hopeless condition, induced by pyæmia, from which, however, he rose again; and finally reamputation effected his cure.

He was also one of the few patients whom I have seen recover from well-marked pyæmia.

Case LIII. *Primary Amputation of Left Leg for Gunshot Injuries, followed on the Twenty-fifth Day by Pyæmia from which Recovery took Place; Stump healed entirely in Eighty-five Days; Stump afterwards became irritable and excessively painful from Chronic Ostitis; Reamputation; Recovery.* — Private Daniel O'Connor, Co. C, Cobb's Legion (Confederate), aged 28, was admitted to the Stanton U. S. Army General Hospital, September 25, 1863, having been wounded on the 21st

instant, by a minie ball, near Madison C. H., Va. He states that the injury was a compound comminuted fracture involving the left ankle-joint. The leg was amputated, on the field, soon after the infliction of the wound, at its middle, by the circular operation. When admitted to hospital the stump presented a ragged and sloughy appearance. It was much swollen and painful. He had considerable constitutional disturbance. The stitches were then taken out of the stump and simple dressings applied, which, however, were kept moist with liquor sodæ chlor. dilut. Porter and a generous diet were allowed.

October 1. — A portion of the flap has sloughed off, and an abscess has formed among the muscles of the leg. An incision was made, and a quantity of pus evacuated. The stump presents a more healthy appearance, but the fever continues. Prescribed quiniæ et ferri citrat. grs. v., to be taken three times a day; the stump to be dressed with aqua calcis; the porter and the nutrients to be continued.

October 15. — The stump continued to do well until yesterday, when it became much swollen, and painful, and to-day presents an erysipelatous appearance. Ordered the ice-dressing to be applied to the stump, the quinine and iron to be continued, and spts. frumenti f. ʒi. to be administered every four hours.

October 16. — In the afternoon he had violent rigors, followed by fever, and at night he sweat profusely. Ordered tinct. ferri muriat. gtts. xx., to be taken every six hours, and the whiskey to be continued.

October 17. — He had several rigors to-day, with fever, sweats, and vomiting. Directed the same treatment to be continued and a sinapism to be applied to his epigastrium. He has great debility.

October 18. — The track of the lymphatic vessels of the thigh is red and inflamed, and the glands of the groin are swollen. Ordered a lotion of lead and opium to be applied to the thigh, the iron to be administered every four hours, and the whiskey every three hours.

October 19. — The swelling of the stump and the inflammation of the lymphatics are less this morning, but his countenance and skin generally present a yellow appearance. He says he feels much better. Directed the same treatment to be continued.

October 20. — He had rigors and fever this morning, but the stump is less swollen and looks better.

October 21. — The inflammation of the lymphatics has disappeared, but the glands of the groin are still enlarged. His bowels being confined, he was directed to take pulv. aloes grs. x., pulv. rhei grs. xx., at once.

October 22. — His bowels have moved freely, and he is better this morning. His spirits and appetite have improved. The stump is less swelled and inflamed, and the granulations are more healthy in appearance.

October 23. — He is more restless this morning, and has considerable fever with gastric irritability. His tongue is dry and coated.

October 25. — His general condition is better. The swelling of the lymphatic glands has entirely subsided, and that of the stump is growing less. His tongue is more moist and his appetite improved. Ordered the iron to be administered every six hours, and the whiskey every four hours, in the same doses respectively as heretofore.

October 29. — He is doing well. An exfoliation from the end of the fibula was removed.

November 4. — The stump is contracting and cicatrizing. An exfoliation from the end of the tibia was removed to-day. Reduced his allowance of whiskey to four ounces daily.

December 15. — The stump has healed. He says that it is painful. His general condition is good.

January 15, 1864. — He continued to complain very much of pain located in the stump. Instead of subsiding it appeared rather to increase as the consolidation of the interior advanced. The cicatrix was observed to be thin, blue-colored, tender, and firmly adherent to the end of the tibia. Some thickening, apparently of the periosteum, was observed on the front of the tibia. This thickening, flattened in shape, extended a distance of one or two inches above the end of the tibia. It was the seat of so much tenderness that the patient would not allow it to be thoroughly examined by the touch. He complained of tenderness also at the end of the fibula. The stump was somewhat warmer than natural, but not swelled as a whole. There was no swelling of the stump whatever, aside from the amount of periosteal thickening already described. It presented no abnormity in color besides the blueness of the cicatrix above mentioned. He said the pain was constant, heavy, and aching in character, and located about the end of the tibia at the periosteal thickening, and at the end of the fibula, being more severe, however, in the former than in the latter locality. He said also that the pain lasted all the while, both day and night, in about the same degree of intensity: if there was any difference it was rather more severe at night. He was ordered to have the iodide of potassium administered to him in full doses, and to have the compound iodine ointment applied over the thickened periosteum. This treatment was continued for some time, and under it the stump-pain abated considerably, but did not disappear. The thickening of the periosteum slowly diminished, and finally went away entirely. After a while the medicine seemed no longer to do him any good, and its administration was suspended; but the heavy, aching pain in the end of the tibia and fibula still continued, and, afterwards, appeared to become worse than ever.

In the month of March it was observed that certain of the posterior muscles of the stump, the gastrocnemius and soleus, especially the former, were gradually contracting, and thus pulling the stump out of shape.

By the fore-part of April the stump had assumed decidedly a wedge-

shape (the apex being at the end of the stump-bones), from progressive contraction of the calf-muscles. The flexor muscles of the leg, the hamstring muscles (namely, biceps, semi-membranosus, and semi-tendinosus), also were becoming contracted, and firmly holding the knee partially bent. He complained bitterly of the pain, which was still accompanied by considerable tenderness about the end of the stump-bones. He was pale, weak, and thin, and his countenance expressed great suffering. Both the local symptoms and the general condition of the patient now demanded that the focus of irritation should be removed without further delay. The symptoms clearly indicated that the osseous tissue of the stump was diseased, and that it should be removed by operation.

Now, in such cases two methods of operative procedure may be employed. We can either cut into the stump, separate the soft parts from the bones, and saw them off at a suitable point, or we can reamputate at some place still higher up. The uncertainty with regard to the extent to which the bones might be diseased in this case, and the large amount of contraction on the part of the calf-muscles determined me to adopt the latter method.

April 14. — The leg was accordingly reamputated, by the author, at the place of election by the double-flap method, the patient being etherized. The muscles presented a red color, and were not fatty. The operation was attended with a good deal of shock, although not more than a tablespoonful of blood was lost. The flaps were carefully coapted and secured by several points of interrupted suture, and several strips of isinglass plaster. Several circular turns of a roller bandage were applied round the stump in order to give it adequate support, and a dose of morphia was administered. Reaction came on promptly.

The *examination of the amputated part* showed the presence of a low grade of *inflammation* in the lower part *of the stump-bones.* On splitting the tibia its compact tissue was seen to present a *dark-red color* and to contain more blood than natural for a distance of nearly two inches above the original stump-end. The *periosteum was easily peeled off* in this locality, (but not elsewhere) and the exposed *osseous surface* was somewhat *rougher than natural, and dark-red in color.* The periosteum itself in the same locality was somewhat thickened and reddened. Within the medullary canal a moderately thick plate of new bone, also dark-red in color, was found attached to the internal surface of the inflamed part of the bone, but nowhere else. This new osseous lamina was but loosely connected with the inflamed bone. The marrow was pale-yellow, soft, and very fatty. It did not exhibit any evidence of being inflamed at any point. It did not even exhibit abnormal vascularity at any point. The end of the tibia was well rounded off, and the medullary canal was sealed up by a thin, smooth, white plate of bone. It was also observed that, at the place of reamputation, the tibia sawed considerably more easily than usual, and that its structure was more

porous and spongy than natural (osteo-porosis). The compact tissue throughout the amputated bone was very porous and spongy, but more so at the end than elsewhere.

About the lower end of the fibula the periosteum was much thickened and *hard like cartilage*. The osseous tissue in the same locality presented evidences of chronic inflammation similar to those seen in the tibia and described above. The marrow of the fibula was fatty and not inflamed.

The stump-end of the posterior tibial nerve was somewhat bulbous, but not very markedly so. The sheath of the nerve appeared to be somewhat thicker than natural, but it was not inflamed, and did not compress its contents. The tissue of the nerve itself presented a natural appearance. The blood-vessels were properly sealed up and sound.

Progress of Case after the Reamputation. *April* 15. — There is a moderate amount of febrile excitement. The stump is but little swelled and in fine condition.

April 16. — He has no fever to-day. The stump is doing well. His tongue is coated but little.

April 17. — Pulse about 100; tongue more coated; dressed the stump and removed all the sutures.

April 18. — The stump is now moderately swelled, and its integument is red (erysipelatous) up to the knee; pulse about 120. Prescribed the lead and opium wash for the stump, hydrarg. chlorid. mite grs. x. to be followed by sal. Rochelle ʒss. and allowed spts. frumenti with nutrients.

April 19. — Bowels not moved; lymphatic glands of groin swollen and painful; condition otherwise about the same. Prescribed pulv. aloes grs. x., pulv. rhei grs. xx., to be taken at once.

April 20. — Lymphatics (superficial) of thigh, tender; hard, like little cords in feel, and the skin over them is discolored so as to exhibit dark-red streaks; general condition better; continued the stimulants and the lotion.

April 21. — Inflammation of lymphatics subsiding; dressed stump and found the major part of it united by adhesion. Prescribed tonics; namely, quiniæ sulph. grs. ii., elixir vitriol. gtts. xx., ter in die sumend.

April 22. — Inflammation nearly disappeared; he is doing well in every respect.

June 3. — He was transferred to Lincoln Hospital, the depot for wounded prisoners of war; *cured*. The stump had a good shape and was in good condition.

The healthy condition of the medullary tissue in this case, and the small amount of disease in the periosteum, show conclusively that this was an instance of primary inflammation of the bone itself; and that its origin was traumatic is rendered probable by the fact that it followed amputation.

Proof that it was primary ostitis.

There can be no doubt that the osteo-porosis (medullization) in this case had an inflammatory origin, and that it had been produced by a very protracted exposure of the osseous tissue to the inflammatory process. The ostitis had lasted over three months, when reamputation was performed. The osteo-porotic condition was also more strongly marked at the end of the bone than elsewhere, since the inflammation of the osseous tissue had commenced at the end of the bone, and was therefore of an older date in that locality than elsewhere.

First pathological change.

When a bone is invaded by the inflammatory process without producing necrosis, the first alteration in its appearance which takes place is the development of a number of red minute spots, which may be exposed to view on the exterior of the bone by stripping off its periosteum, and in its substance by making a section with a saw.[1] After the inflammatory process has continued for a longer time, the osseous tissue becomes diffusely reddened or accquires a rosy hue.[2]

Induration or sclerosis among the first changes.

The first effect of the inflammatory process upon the osseous tissue, besides the alterations in color above mentioned, has seemed to me to be an increase in its density, that is, the production of sclerosis or induration. I have observed, not unfrequently, in specimens of necrosis occurring in the shafts of the long bones, whose formation had been accompanied by acute ostitis, that the structure of the necrosed piece seemed to be denser than natural, and that the specimen appeared to have a greater weight than that possessed by a similar piece of healthy bone. I have also noticed several times that, in making longitudinal sections of stump-bones affected with suppurative osteo-myelitis wherein the inflammatory process had recently extended itself from the marrow to the osseous tissue, the inflamed portion of the bone was harder to saw than the healthy part of it.[3] I therefore believe that, speaking generally, among the first effects produced by ostitis is induration of the osseous tissue.[4]

[1] Vide Cases X. and XI., also Plates II., III., and VI.

[2] Vide Cases X. and XLVIII., also Plates II., III., X., and XI.

[3] Vide Cases X., XXIX., etc.

[4] Concerning *induration* of the osseous tissue as one of the results of the inflammatory process operating in that tissue, Mr. Barwell, after stating that inflammation producing simple induration of bone commences by some enlargement of the lacunæ, and that at the same time, the canaliculi become increased both in size and number, says: "It cannot fail to strike the attentive reader, that, in the first of these conditions, [inflammatory induration] the lacunæ and canaliculi being increased in size, the actual osseous substance must be diminished,

But after the inflammatory process has continued for a considerable length of time, the diseased portion of the bone becomes lighter and more porous than natural. This is precisely what happened in the case just related.

We have also seen that it occurred in several others of our cases. This condition is called osteo-porosis. It denotes that the portion of osseous tissue affected by it has been subjected to inflammatory irritation for a considerable length of time.[1] It is produced by an interstitial metamorphosis of the osseous elements occupying bone territories or lamellæ into medullary tissue in the way already pointed out.[2] The Haversian canals of the compact structure were found to be enormously enlarged. Osteo-porosis is a condition of bone in which interstitial medullization has occurred. It is thus that the rarefaction of osseous tissue is produced.[3]

Osteo-porosis later.

The following case affords another example of inflammatory osteo-porosis. It also possesses sundry other interesting features.

Case LIV. *Gunshot Fracture of the Arm which united, and, being followed by Chronic Ostitis, came apart again Nine Years afterwards; Amputation; Recovery; Osteo-porosis and Osteo-myelitis found in the Amputated Member.* — A man, admitted to the Saint Louis Hospital in the service of M. Gerdy, had had his right arm broken, nine years previously, by a gunshot projectile. The consolidation of the fracture took place without unusual delay. The patient believed himself permanently

and yet the bone is condensed; a combination which at first sight seems impossible. But if the functions of the bone-cells and their branches be considered, this apparent discrepancy becomes not only reconciled, but the interdependence of the two processes will be found necessary. The lacunæ and canaliculi being the nutrient portions of the bone, it follows that their assumption of more active performance would be followed by increased nutrition of the parts they supply; hence to increased condensation of those parts; — to greater hardness of the bone. This condition has its physiological analogies, for not only is dentine more tubular than bone, but where a hard condition is necessary there do we find a more complete tubular arrangement of elements. The hardest ivory is most closely permeated by tubes. The external shell of certain crustaceæ, as the crab and the lobster, becomes tubular instead of cellular in those hard, tooth-like projections on the inside of the claw. In fact, this commencement of the inflammatory process is in bone, as in other parts, increased nutrition, and in its least marked form is hardly, if at all, distinguishable from the condition of growth in the bones of very young animals; it is simply a very active condition of the cells of the structure." — See *Diseases of the Joints*, p. 239, Am. ed.

[1] Vide Case LI.

[2] See also the account of microscopical examination and the comments belonging to Cases XLVIII. and LI.

[3] Mr. Barwell says, while speaking of inflammation of the osseous tissue: "If the nutritive activity of the cells, which constitutes an indurating inflammation, be increased to a formative action, so that they not only grow still further in size, but actually multiply within the lacunæ, then follows absorption or softening of the intercellular osseous substance to support this increased cell-growth; ultimately discharge of the cells from the lacunæ into the softened mass."—See *Diseases of the Joints*, p. 240, Am. ed.

cured of his fracture of the humerus, when, at the end of nine years, inflammation was awakened and compelled him to apply for surgical assistance. An effort to prevent suppuration was vainly made; an abscess came on, which, of necessity, was opened at the level of the fracture. Afterwards, some small fragments of necrosed bone, that appeared at the orifice of the wound, were removed; and, while waiting for a cicatrization that did not occur, the callus softened and ended in complete solution. In vain was the arm placed in an apparatus for fracture; consolidation did not take place, suppuration persisted, and at the end of about six weeks of waiting, the digestive organs became affected, and hectic fever declared itself. Seeing then that the symptoms became more aggravated day by day, the arm was amputated about its middle, and the patient recovered without any accident.

The bones removed were the seat of an *obvious inflammation. They were furrowed and riddled with holes*, which were filled up with vessels. The marrow was slate-gray in some places, red in others, and suppurating at the points corresponding to the wound. The inflammation, which primarily extended itself to the articulation of the elbow, it being very near the fracture, had induced anchylosis by the soldering of the bones of the fore-arm to the humerus, with a material having but little solidity in other situations.[1]

Sclerosis and osteo-porosis sometimes consentaneous.

In the same bone we sometimes find one portion affected with inflammatory osteo-porosis, while another part is the seat of inflammatory induration. The following case is a good illustration of this pathological fact. While perusing the case last related, the reader cannot fail to observe that the *marrow also was inflamed*, that it was *slate-gray* in some places, *red* in others, and *suppurating* at the points corresponding to the wound. In the case about to be related, the medullary tissue was likewise inflamed and suppurating at the seat of the inflammatory osteo-porosis, namely, the condyles of the femur and the head of the tibia.[2]

CASE LV. *Gunshot Wound penetrating the Femur, followed by the Exfoliation of much Bone, and Anchylosis of the Knee-joint; Suppuration in the Cancellous Tissue at the Knee occurred Nine Years afterwards; Can-*

1 Vide *Traité Pratique de la Suppuration*, etc., par E. Chassaignac, tome i. p. 506. Paris, 1859.

2 On this subject Ollier remarks in substance, that irritation of one of the elements of bone is always transmitted more or less to the others, and is always diffused more or less beyond the point originally affected. As a result the same bone may present all the degrees and varieties of inflammation. In one part there may be undue medullization (osteo-porosis) in another eburnation; here, suppuration and necrosis — there, an exostosis, or ossification of the marrow. See *American Journal Medical Sciences*, January, 1868, p. 151. The remarks perfectly accord with my own observations; and the more I see of and reflect upon the pathological processes occurring in bone, the more thoroughly am I convinced of their truth.

celli enlarged (Osteo-porosis); Amputation; Tissue of Shaft of Femur generally found to be condensed; Result fatal. — Pierre-Jean Gely entered La Pitié, January 20, 1840. He had received a gunshot wound of the right thigh in the days of July, 1830. The ball, fired from an elevated position (the colonnade of the Louvre), struck the bone a little above and behind its external condyle. It was extracted immediately, without difficulty, and did not appear to have penetrated deeply. Nevertheless, the inflammation was violent, and speedily extended to the knee. Numerous abscesses formed about the joint, and fragments of the femur were discharged in abundance. Later, the skin of the anterior part of the leg ulcerated at several points, and allowed some irregular bony flakes to escape. Finally, the patient recovered with the knee anchylosed at an obtuse angle.

Gely followed the occupation of a shoemaker, to which his infirmity had consigned him. His constitution remained robust and his health excellent until about nine years after the wound, towards the middle of December, 1839, when he experienced, without any known cause, acute pains in the knee. He was soon compelled to quit work and apply for surgical relief.

When he entered the hospital his knee was considerably swelled; skin tense, shining, and presenting a livid hue at the level of the cicatrices; considerable augmentation in volume of the condyles of the the femur; they overlapped the corresponding surface of the tibia in every direction; the latter was not swelled nor deformed. The manual examination to detect fluctuation occasioned much pain. He had a pale color, debility, looseness of bowels for three days, and fever with nocturnal exacerbations.

July 22. — Fluctuation (deep-seated) was recognized at the level of the internal condyle; an incision gave issue to a great quantity of pus.

July 25. — A new abscess was discovered on the outer side of the swelling; opened it. No denudation of the bone could be discovered in either abscess.

July 27. — Sanson practiced amputation. Being struck with the *hardness of the bone*, and the length of time required to divide it, this surgeon scrutinized the sawn surface and diagnosed eburnization. This circumstance led him not to attempt to get immediate union, and the lips of the wound were kept apart with charpie.

After some alternations of better and worse, the patient died on the evening of August 18.

Autopsy. — The lungs, the brain, and all the viscera are healthy.

The periosteum is a little loosened on the inner side of the stump-bone. The marrow projects somewhat beyond its extremity; but, on splitting the bone, no appreciable lesion is discovered, nothing more than in the articulation of the hip. The *hardness of the bone* arises less

from a real eburnization, than from an *augmentation of its compact* tissue, which also encroaches upon the medullary canal.

Anatomical Examination of the Amputated Member. — The two abscesses opened during life did not come from the bone.

At the upper part of the external condyle of the femur, a sunken cicatrix marks the place of entrance of the ball, the course of which we can trace, being represented in the soft parts by a fibrous cord of the size of a goose-quill, and in the bone, which it penetrated to the depth of about eight tenths of an inch (two centimetres), by an irregular nucleus of compact tissue lodged in the midst of the cancellous tissue.

An incision with a saw, made transversely to the course of the ball, having detached the anterior half of the condyles of the femur and of the tibia in a single piece, allowed the interior of the anchylosed articular epiphyses to be examined. But the *cancelli enlarged*, and communicating with each other everywhere in the condyles of the femur and the head of the tibia, were filled with pus of a creamy consistence and color, the perfectly inflammatory character of which impressed Sanson. By the simple inclination of the cut surface the pus flowed out from the cancelli so that a stream of water easily completed its removal.[1]

In cases similar to the foregoing, Ollier considers that traumatic irritation of the bone itself may produce an immediate increase in the number of osteoplasts, or, on the other hand, may cause a hyperplasia of the marrow cells in the interior of the Haversian canals. In the latter case the process may continue by disappearance of the bony substance, with rarefaction and subsequent suppuration of the parts previously medullized. Or, if the irritation cease before this effect is produced, the process of decalcification may be arrested and the formation of osteoplasts resumed. This may even go so far as to result in a veritable eburnation — in this case the cure of the inflammation — or it may, as before observed, be the primary effect of a chronic, slow, and long continued irritation.[2] These views coincide with my own.

Osteo-porosis and sclerosis in same bone.

It is worthy of special remark that in the case just related, the portion of the femur in which the inflammatory process had existed longest was found to be in a state of osteo-porosis, while the rest of the bone that had been subjected to inflammatory irritation was in a state of induration. It is also worthy of special remark, that the abnormal hardness of the bone was produced by augmentation of its compact tissue — was due

[1] Morel-Lavallé's case. Vide *Traité Pratique de la Suppuration*, etc., par E. Chassaignac, tome I. pp. 499, 500. Paris, 1859.

[2] See *American Journal Medical Sciences*, January, 1868, p. 151.

to increase in the number and thickness of the osseous lamellæ with corresponding diminution in the number and size of the medullary spaces and the Haversian canals.

Inflammation of the osseous tissue not unfrequently proceeds further than the stage of osteo-porosis, and produces suppuration. If the seat of the inflammatory process be circumscribed, then a chronic abscess of bone may be the result. A transformation of the osseous tissue into granulation tissue and then into pus takes place through the excitation of its histological elements by inflammatory irritation, through a limited space.

Ostitis may terminate in abscess.

The next case is an instance of chronic abscess of bone. In such cases the osseous tissue surrounding the abscess is usually in a state of inflammatory induration to a considerable depth. The formation of purulent matter appears to be preceded by a state of local inflammatory osteo-porosis, exterior to which the osseous tissue is indurated. As the red granulation tissue becomes metamorphosed into pus, the osseous partitions continue to disappear, until finally the cavity of an abscess lined with granulation tissue is formed in the bone.

On this point Mr. Barwell says: —

"The actions thus briefly described are remarkable, not only in themselves, but also on account of the similarity in their results to those of inflammation in soft parts, in which we find induration, suppuration (circumscribed or diffuse), and gangrene. In both it appears that the first effect of a tolerably healthy inflammation is to harden and condense the tissue, in which it occurs, and, subsequently, to soften and convert it into pus. The process in bone is, however, much slower, and months may be consumed in the establishment of a small abscess, which would have formed in about as many hours in the subcutaneous areolar tissue; but this difference is by no means generic, and although there may be variation in the mere rapidity or slowness of the process, the actions are alike."[1]

Case LVI. *Abscess (chronic) of Upper Part of Tibia, with Necrosis, of Many Years' Duration; cured by a Surgical Operation;* reported by Dr. E. S. Cooper, of San Francisco. — J. S., aged 29, was attacked with disease of the tibia at the age of five years, in consequence of a slight bruise resulting in inflammation. Several small pieces of bone were lost at different times, after each of which the patient generally improved to such an extent as to consider himself entirely well,

[1] Vide *Diseases of the Joints*, p. 233. Am. ed.

for a year or two. The attack of inflammation, by which he was led to consult me, occurred about four weeks since, during which time he has suffered much, and is now so lame as to be hardly able to walk at all. There are two sinuous channels leading from the surface to the diseased tibia, the centre of which can be penetrated with a probe readily, and carious bone felt. There are several cicatrices at different parts over the tibia, at which exfoliated bone has formerly been discharged. The mouths of the sinuous channels are directly over the lower part of the knee-joint, but both of them course obliquely downwards.

Operation. — Chloroform having been administered, an incision five inches long was made, commencing at the lower edge of the patella, and continuing down the spine of the tibia, directly to the bone. A transverse incision of one and a half inches was then made over the tuberosity of the tibia, after which the chisel was taken and the soft parts raised up from the front of the bone, and both its sides. This brought into view an excavation in the interior of the tibia filled with a soft substance, which on being scooped out gave vent to a small amount of purulent matter, and displayed a small cavity in the bone lined by a thick pyogenic membrane.

In dissecting this away, a small amount of pus was seen issuing from the parts below, when, on examination, *a large abscess was found in the bone* whence the matter was discharged. Its anterior wall was then bored through, and a considerable quantity more of pus escaped. The cavity of the abscess was now found to be about two thirds the size of a hen's egg, and containing a large mass of pyogenic membrane in numerous folds. This was carefully removed, and the surface of the bony wall of the abscess cleared of all soft substance, when the operation was concluded.

The wound was dressed from the bottom with lint, and an evaporating lotion applied.

The patient suffered little or no pain after the operation, and did well in every respect.

Five months after the operation he was walking almost as well as ever, though the wound was not entirely healed.[1]

Symptoms of ostitis.

The symptoms produced by inflammation of the osseous tissue are the following: Heavy aching pain located in the diseased bone, and generally more severe during the night than during the day-time, local warmth and tenderness under pressure, swelling (œdematous) of the soft parts without reddening of the skin. Generally there is also loss of appetite, sleeplessness, and progressively increasing pallor, emaciation, and debility.

[1] Vide *American Medical Times*, June 21, 1862, p. 347. This account has been made by abridging somewhat the report published by Dr. Cooper.

But it is probable that when the intensity of the inflammatory process in bone is very great, it may destroy the vitality of the osseous tissue outright, by destroying the integrity of the bone corpuscles in a manner analogous to what we have seen take place in the medullary tissue and in the soft parts extraneous to bone; and if, at the same time, a strong putrefactive tendency exists in the circulating fluids and in the diseased tissue itself, a wet or mephitic gangrene of bone may be produced analogous in many respects to the wet gangrene of the soft parts.[1] Ostitic gangrene.

Treatment. — The remedial measures indicated for the relief of ostitis may be conveniently divided into the general or constitutional, and the local. If the disease be acute and the vascular excitement great, it will be advisable to moderate it by the administration of such remedies as the veratrum viride or aconite, and by saline draughts, such as the neutral mixture (liquor potass. citratis), etc., and, in extreme cases, by venesection. Opiates should also be prescribed with the view to allay pain. In the sub-acute and chronic forms of ostitis, the iodide of potassium is almost always found to be a remedy of very great value. It should be administered in the way already pointed out.[2] The local or tropical treatment required for ostitis does not differ essentially from that required for osteo-myelitis,[3] to which the reader is respectfully referred. If, however, the disease proceeds to the formation of a veritable abscess of bone, which, by the way, is usually called a chronic abscess of bone, it requires precisely the same plan of treatment as the chronic abscess of the marrow. The patient having been etherized, the osseous abscess should be laid freely open by employing the trephine, and Hey's saw, and the chisel, and the gouge, according to the requirements of the case. Then, all the diseased tissue should be removed from the interior of the abscess. Subsequently, the after treatment should be conducted with a view to make the wound of operation heal from the bottom, which can readily be accomplished by dressing it daily with dry charpie carried to the bottom. Finally, amputation may sometimes be necessary, as we found in the case of O'Connor (No. LIII.). Chronic abscess of bone when it involves an articular epiphysis also generally demands amputation. Treatment. Perforation of the bone.

[1] Thus, then, we find that even in the bones, inflammation consists of actions precisely similar to those which constitute that abnormal state in cartilage, or in areolar tissue, namely, a superabundant growth of the cells of the tissue, which, destroying the intercellular substance, become converted into granulation or pus-cells, or may, by becoming fatty and losing quickly their nutritive powers, cause the integral death of the dependent tissues. Vide Barwell, *On Disease of the Joints*, p. 241. Am. ed.

[2] Vide pp. 419, 420, of this Section. [3] Vide pp. 421, 422, of this Section.

CHAPTER FOURTH.

OF CARIES.

Signification of Term "Caries." — Disappearance of Earthy Material and of Ostein. — Presence of Granulation Tissue and of Pus. — Other Pathological Changes. — Most frequent in the Spongy Tissue of Bones. — Diffuse and Circumscribed Caries. — Simple, Scrofulous, and Syphilitic, with Certain Points of Difference. — Phagedenic Caries. — Caries a Result of Ostitis (degenerative). — Distinction between Caries and Osteo-porosis. — Process of Transformation in Caries. — Caries Necrotica. — Influence of Cachexiæ, of Age, Privation, etc. — Symptomatology. — Caries not always accompanied by Formation of Purulent Matter. — Caries with Absorption; with Condensation. — Other Signs of Caries. — Offensive Odor. — Treatment. — Remove the Cause. — Disinfectants. — Operative Procedures.

THIS term is here used to signify *ulceration of the osseous tissue.*[1] In certain diseased conditions of the bones the osseous structure wastes away, the continuity of the osseous surface becomes destroyed, and the affected bone presents an excavated, eroded, and worm-eaten appearance. The excavations into the osseous structure, produced by the ulcerative process, are generally filled with either red or gelatiniform granulation tissue, which is commonly found to be suppurating at the same time. In the portion of the osseous tissue which surrounds the ulceration it not unfrequently happens that the earthy material disappears to so great an extent as to permit said tissue to be easily cut with a knife, and to be penetrated by a probe to some depth. But, in other cases, the animal matter, the ostein, disappears here and there, in small spots, leaving the earthy material as little, friable, cretaceous lumps, soaked in pus and surrounded by granulation tissue. When the ulcerative process (caries) commences on the surface of a bone, the periosteum always becomes reddened, thickened, and, sooner or later, detached in the locality of the caries, purulent matter collects between that membrane and the carious

Sometimes earthy matter, sometimes ostein disappears.

[1] Ulceration of the osseous tissue, aside from that which was required to effect the separation of necrosed fragments, was not, according to my experience, a matter of frequent occurrence in our military hospitals during the late war. I did, however, occasionally meet with such an ulceration of the osseous tissue in the stump-bones of amputated limbs, and in bones that had been fractured by gunshot projectiles, but generally at an advanced period in the treatment. Some of these patients had a strumous diathesis. I also know of an instance of chronic ulceration of the osseous tissue which was produced by the presence of a bullet.

surface, which after a time perforates said membrane, and being discharged into the connective or areolar tissue external to it, produces an abscess there. At the same time the inflamed periosteum in the neighborhood of the ulceration not unfrequently proceeds with the development of new osseous tissue in plates and nodules having an irregular shape, and sometimes erratic bony growths called osteophytes are also found in the soft parts external to the periosteum at the seat of the disease. By the sub-periosteal development of new osseous laminæ the bone may become considerably thickened in the neighborhood of the carious portion, especially after the ulcerative process has lasted a long time.

New bone formed.

In the extremities, caries occurs less frequently in the compact tissue of the shaft of the long bones than in the spongy structure of their epiphyses. It is also met with less frequently in the long bones, than in the irregularly shaped bones of the tarsus and carpus. It is not unfrequently met with in the spongy tissue of the sternum.

More frequent in spongy than compact tissue.

When the ulcerative process involves the osseous tissue to large extent, the whole joint end of the tibia or the femur at the knee, for example, it is called *diffuse caries* (*caries diffusa totalis*); but, when it is confined to a limited portion of the osseous tissue, it is called *circumscribed caries* (*caries circumscripta*). The former occurs but rarely, while the latter is not unfrequently met with. In circumscribed caries the osseous tissue surrounding the portion involved in the ulcerative process is generally in a state of inflammatory induration. Furthermore, the ravages of circumscribed caries are, for the most part, limited to adults.

Diffuse and circumscribed.

Several varieties of caries are recognized. They are the *simple*, the *scrofulous*, and the *syphilitic*. The process by which a fragment of necrosed bone becomes separated from the living osseous tissue which surrounds it affords an excellent example of the simple variety of ulceration of bone, or simple caries. The scrofulous and syphilitic forms of the disease are much more destructive than the simple variety. They derive their special virulence from the depraved constitutional conditions or dyscrasiæ with which they are accompanied. While the simple variety of caries is a purely local affection, the others are constitutional in their nature, and while the first named is generally amenable to local treatment, the other forms cannot be cured without constitutional medication. To the varieties of caries enumerated above, the *phagedenic* should also be added. It is, however, but seldom

Several varieties.

met with, and is frequently dependent, to greater or less extent, for its virulence, upon either the scrofulous or the syphilitic cachexia.[1]

Always inflammatory and degenerative.

Again, caries must be considered as one of the results of the inflammatory process operating in bone. In all cases, without exception, where it is produced, it is occasioned directly by an *ulcerative inflammation* of the osseous tissue. Hence it is that the morbid process by which caries is effected, is sometimes called a *degenerative ostitis*, in order to distinguish it from the formative varieties of osseous inflammation, especially those which are accompanied by sclerosis of the osseous tissue.

Relationship of osteo-porosis and caries.

Between the abnormally spongy condition of the osseous tissue produced by the inflammatory process, which we have already had occasion to describe under the name of *osteo-porosis*, and *caries*, a remarkably close relationship exists. In both of them the changed appearance of the osseous structure is occasioned by inflammatory action. In both of them the histological metamorphoses produced under the stimulus of inflammatory irritation are strictly analogous up to a certain point in their development. After that point has been attained, the inflammatory transformations of the histological elements continue to occur in cases of *caries*, and cease to occur in cases of *osteo-porosis*. In a great many instances the former is only a more advanced stage of the latter, or, speaking more exactly, while both of them are produced by a degenerative ostitis, the former (*caries*) exhibits that pathological process to us in a more advanced stage than the latter (*osteo-porosis*) does. In cases of caries, the holes and cavities excavated in the osseous tissue have a larger size than they do in osteo-porosis. In cases of caries, the granulation tissue contained in the holes and cavities is generally found to be suppurating, that is, undergoing transformation into purulent matter, while in cases of osteo-porosis the new granulation tissue is, for the most part, found to be not undergoing that transformation. Such are the leading points of both resemblance and difference between caries and osteo-porosis.

Process of transformation.

When caries is about to occur in the spongy epiphysis of a long bone or in the cancellous structure of the irregularly shaped bones of any portion of the body, the usual phe-

[1] Vide *Medico-chirurg. Transact.*, vol. xxxix. p. 285, for an account of two cases of phagedenic ulceration of bone related by Mr. Cæsar Hawkins. One of them occurred in a strumous subject. In the other case the disease involved the calvarium. Vide, also, Stanley *On Diseases of the Bones*, pp. 71, 72, Am. ed., for an account of three additional cases, in all of which the phagedenic ulceration involved the tibia. One of these patients was fifty-three, another seventy, and of the third the age is not stated.

nomena of protracted or reverse osseous inflammation are presented. The osseous laminæ become softened and waste away under the operation of the inflammatory process. Through its agency, the calcareous salts disappear from the hard intercellular substance of the diseased bony plates, the firm ostein melts down into the soft intercellular substance of granulation tissue, and the bone-corpuscles multiply themselves and become transformed into granulation cells. In this way, through the operation of the inflammatory process, the osseous laminæ which enter into the structure of the several partitions between the cancelli become converted into new granulation tissue, the bony partitions themselves become thinned thereby, and the cancelli enlarged to the same extent. In this way, if the operation of the inflammatory process be continued, the osseous septa finally disappear by metamorphosis into new granulation tissue (inflamed marrow), the cavities of several cancelli become laid into one, or coalescent, until finally, in extreme cases, a large portion of the epiphysis of a long bone, or the spongy substance of any other bone involved in this morbid process, may become transformed into a flesh-like mass of granulation tissue permeated here and there by a thin and brittle osseous network, the remains of the bony partitions which originally separated the cancelli. But while this is taking place, the new granulation tissue itself is liable to undergo a destructive transformation through the agency of the inflammatory process — is liable to be metamorphosed into purulent matter, to greater or less extent, even while it is yet being produced. This transformation is effected through the conversion of the proliferating granulation cells into pus corpuscles, and the soft intercellular substance of granulation tissue into the liquid intercellular substance of purulent matter.

Caries necrotica.

If the granulation tissue contained in the carious cavity be rapidly transformed into purulent matter, that is, if the process of conversion be very active, it happens, not unfrequently, that minute fragments of bone like grains of sand, both coarse and fine, which, when examined with the microscope, are found to contain lacunæ, canaliculi, etc., are detached and washed away in the purulent discharge. This constitutes the so-called *caries necrotica*, and, for the most part, denotes that the ulcerative process is advancing with considerable rapidity in the diseased bone.

When caries occurs in the compact tissue of the long bones, which, indeed, is but seldom when compared with the frequency of its occurrence in the spongy structure of their epiphyses, the

histological metamorphoses attending its development are essentially the same as those presented by it in the cancellous tissue.

As already intimated, if the *caries* be *circumscribed*, the osseous tissue surrounding the seat of the ulcerative process is generally found to be in a state of inflammatory induration (sclerosis), and sometimes also the bone as a whole exhibits considerable thickening in that situation (periostosis).

On the subject of caries Virchow remarks: "The whole process is a *degenerative ostitis*, in which the osseous tissue changes its structure, loses its chemical and morphological characters, and so becomes a soft tissue which no longer contains lime. The tissue, which fills the resulting vacuity in the bone, may vary extremely according to circumstances, consisting in one case of a fattily degenerating and disintegrating substance (the bone-corpuscles perishing), and in another of a substance rich in cells and containing numerous young cells; this latter is formed by the division and proliferation of the bone-corpuscles, and the newly produced substance is very analogous to marrow. Under certain circumstances this substance may grow to such an extent, that — if we again borrow our illustration from the surface of the bone, where a vessel sinks in — the young medullary matter sprouts out by the side of the vessel, and appears as a little knob, filling one of the pits in the surface. This we call a *granulation*." [1]

Granulations from bone.

But the course of *degenerative ostitis*, which, in all cases, without exception, is the efficient cause of caries, is often modified very much by the presence of a depraved state of the patient's constitution, such, for example, as that which accompanies the strumous and the syphilitic dyscrasia. As the ulcerative process, when it occurs in the soft parts, may be made to pursue a particular course, and the ulcerated surface be made to present a peculiar appearance, through the agency of these cachexiæ, even so the ulcerative process, when it occurs in the osseous tissue, is often very much aggravated in respect to both its progress and results by the operation of the same deleterious causes. Hence it is that we generally find in cases of simple ulceration of bone, especially those wherein a necrosed fragment is separated by this process from the living osseous tissue with which it happens to be connected, the softening of the osseous material does not extend to any considerable distance beyond the ulcer itself, while in cases of strumous caries we not unfrequently find that the softening of the osseous material is very marked, and that it often extends to a consider-

Influence of dyscrasiæ.

[1] Vide *Lectures on Cellular Pathology*, p. 464. Am. Ed.

able and, sometimes, to a great distance from the seat of the ulceration. In the one case the range of the destructive process is very much more limited than it is in the other. The former always belongs to that variety of caries which is called *circumscribed*, while the latter not unfrequently deserves the appellation of *caries diffusa*. Herein we are also enabled to appreciate the difference between *healthy* and *unhealthy ulceration* of the osseous tissue. The first named, for example, often consists in reality of an effort on the part of nature to detach and cast off a fragment of dead bone or some other foreign body, without the destruction of an unnecessary quantity of the osseous tissue, while in the second named the morbid process is not circumscribed by any such narrow boundaries, and is far more destructive in its tendency. The former constitutes what has been called a *healthy*, and the latter what has been denominated an *unhealthy inflammation* of the osseous tissue. We are thus enabled to perceive that there is a similar difference beween the progress and results of healthy and unhealthy inflammations when they occur in the bones, to what there is when they occur in the soft parts. Unhealthy inflammations of the osseous tissue are generally *dyscrasic* in character. They prove more destructive to the osseous tissue in their results than healthy inflammations do, because in them there is superadded to the destructive tendency of the inflammatory process properly so called, some of the destructive effects of the special dyscrasia itself, whether that dyscrasia be syphilitic or strumous. Sometimes, however, unhealthy inflammation of the osseous tissue is not only *dyscrasic* in its character, but also occurs in a subject enfeebled by age, or by want, or by exposure. It is in such subjects that we most frequently meet with the *phagedenic ulceration* of bone. Indeed, it is in the same class of subjects that we are very apt to meet with *phagedenic ulceration* of the soft parts.

Healthy and unhealthy ulceration.

Symptoms of Caries. — As we would be likely to anticipate from the fact that caries is always a result of inflammation of the osseous tissue, we find that the first symptoms pertaining to caries are frequently those which belong to an inflammation of that tissue, which have elsewhere been described at sufficient length. These symptoms are generally followed, sooner or later, by the formation of an abscess in the soft parts near the seat of the caries. This collection of purulent matter usually has its origin in the escape of pus from the ulcerating bone into the parts external to the periosteum. On incising such an abscess and exploring it with a probe,

it is generally found that the cavity of the abscess communicates with carious bone, the precise condition of which can, for the most part, be satisfactorily determined, by taking sufficient pains in conducting the examination.

Caries without suppuration.

But it should also be borne in mind that the ulceration of bone (caries) is not always attended with the formation of purulent matter. This grows out of the fact that the degeneration of the osseous tissue occasioned by the inflammatory process may proceed only so far as to transform the osseous into granulation tissue, without going on to metamorphose the young granulation tissue into purulent matter at all. It is in this way that the bodies of the vertebræ and the bones of the tarsus sometimes disappear to great extent, through the agency of the inflammatory process, without the occurrence of any suppuration whatever. The hard osseous structure becomes transformed into soft granulation tissue, and thus disappears from our view.

Transformation and absorption.

The granulation tissue in its turn may vanish from our sight by molecular absorption, especially when it is not exposed to the action of the atmosphere, and is, at the same time, subjected to the operation of pressure. It is also probable that both of these processes, that is, the transformation of the osseous into granulation tissue and the absorption of the latter, may go on at the same time, and thus we may not be able to see much granulation tissue at any one time. Under such circumstances it might, at first sight, even appear that the portion of osseous tissue subjected to pressure is being removed by a process of simple liquefaction and absorption, when, in reality, its disappearance is occurring in the way above mentioned. That the removal of osseous tissue, when it occurs without the formation of purulent matter, is occasioned by the inflammatory process, is not unfrequently proved by the fact that the bony structure surrounding the seat of the caries has undergone an inflammatory condensation to considerable extent.

Condensation.

Caries without suppuration has, for the most part, been observed only in the cancellous tissue, namely, in the bodies of the vertebræ and the bones of the tarsus. Mr. Cæsar Hawkins, however, once met with it in the compact tissue of the cranial bones. In that case a large part of the calvarium disappeared spontaneously, and without the formation of any purulent matter. The neighboring osseous tissue was thickened and condensed by inflammatory action, thus showing conclusively that the destructive process was inflammatory in its nature. Thus much upon this obscure and important subject.

Generally, when caries occurs in the extremities, or in other portions of the body where the diseased bone is not so deeply covered by the soft parts as to preclude a critical surgical examination, such as the anterior and lateral aspects of the thorax, and the vault of the cranium, the diagnosis is established mainly upon the condition which the diseased bone is found to present. If it be affected with caries, it will be found to exhibit loss of substance occasioned, not by wounds, nor by necrosis, but by the ulcerative process. The excavations and holes thus formed will be discovered to be more or less completely filled with soft granulation tissue, which bleeds copiously on wounding it with the probe. The osseous ulcers will be found to have irregular and uneven bases, because the degenerative process has extended to different depths at different points. Oftentimes the osseous tissue at the base of the ulcer will be found to be much softer than natural, and readily penetrable with a probe, especially in cases of the scrofulous form of the disease. The softened osseous tissue is sometimes endowed with exquisite sensibility; but that does not always obtain. This circumstance diminishes in a corresponding degree the value of this symptom. When, however, the carious surface happens to be keenly sensitive or painful under the injury done to it by probing, it affords a reliable symptom of the disease. But it must not be inferred that caries does not exist even when no exaltation of the sensibility is present.

Other signs.

It may, however, be sometimes inferred in cases where, for any cause, we cannot subject the diseased bone to examination with even a probe, that ulceration of the osseous tissue is actually present, if we find the purulent matter discharged has an odor *very offensive, and resembling that of the pus from a carious tooth* or *a carious jaw-bone*, and contains the phosphate of lime in excess, together with small fragments of osseous tissue like grains of sand (*caries necrotica*), which, when examined with the microscope, are found to exhibit lacunæ and canaliculi. Under such circumstances, it will, not unfrequently, be found, that the ulceration of the osseous tissue is connected with a preëxisting necrosis, and has for its object the detachment and removal of a fragment of dead bone.

Offensive pus.

Treatment of Caries. — The abscesses in the soft parts surrounding an ulcerating bone should be promptly and freely incised. Care should also be taken that as small a quantity of matter as

possible is allowed to remain in contact with the carious surface.[1]

Cleanliness, deodorizers and antiseptics.

By securing the discharge of the purulent matter as soon as it is formed, it sometimes happens that an ulcer of the bone heals without any further trouble.[2] It is also found to be advantageous in many cases to inject a deodorizing and antiseptic wash, such, for example, as aqua chlorinata, liqueur de Labarraque diluted (part 1 to 12), acid muriatic. diluted (part 1 to 100), or tinct. iodine, diluted (part 1 to 2 or 3 of water). Each of these lotions will prove beneficial when properly injected and otherwise judiciously employed. After prolonged use has rendered the diseased parts accustomed to either of these washes, its strength may be cautiously increased with advantage to the patient. M. Chassaignac has strongly recommended the muriatic acid wash.

Sublata causa.

In the next place the cause of the caries should be carefully sought for and removed. If it be found to be dependent upon the irritation occasioned by the presence of a foreign body, such as a fragment of dead bone in a case of central necrosis, or a bullet imbedded in the osseous tissue, said foreign body should be extracted. The carious process will usually be seen to subside, in such instances, soon after the removal of the cause of the irritation which has produced it. If the caries has been produced by the scrofulous or the syphilitic dyscrasia, which, by the way, happens not unfrequently, it becomes necessary to correct the dyscrasia as the first step in the cure of the ulceration of the osseous tissue. The constitutional treatment will be such as is required for the relief of the strumous and the syphilitic forms of ostitis respectively. The strumous subject will be benefited by a nourishing diet with life in the open air, and the administration of ferruginous tonics, such as tinct. ferri muriat., etc., of preparations of iodine such as Lugol's solution or perhaps syrup. ferri iodid., of cod-liver oil, and in cases where the appetite is poor, the bitter tonics should also be employed. The syphilitic subject will require a judicious mercurial course if he has not already been subjected to it, the

[1] For this purpose the evacuative incisions should be made not only *promptly, freely, and as often as the changing condition of the diseased part requires*, but, also, in a *depending position*. The posture of the limb should likewise be such as favors in the highest degree the outflow of the purulent matter.

[2] When, from any cause, an *exacerbation of the degenerative ostitis* that occasions the caries occurs, it is often advisable to abstract blood topically with either leeches or cups, and, sometimes, in cases where the local heat is very great, benefit may be derived from applying the cold-water or even the ice-dressing, for a time, with a view to moderate the local inflammatory excitement. But, generally, cases of caries require warm applications to be made to the affected part, or, at least, such as are not positively cold in their nature.

administration of the iodide of potassium and various tonic remedies, with nutrients and cod-liver oil for the purpose of building up his strength. Of course the outline only of the plan of treatment adapted to the relief of the strumous and the syphilitic cachexiæ is here sketched.

But it happens not unfrequently in the treatment of caries that all other means of affording relief having failed, we are compelled to resort to operative procedures with a view to effect the removal of the diseased osseous tissue itself. Our predecessors cauterized the carious surface with a hot iron, and oftentimes with good effect. The removal of the diseased osseous tissue has also been accomplished by employing the rasp and the gouge; but the result of such operations has not always been satisfactory. Sometimes such patients have lost their lives by pyæmia induced apparently by the operation; and sometimes, where this result has not been produced, the employment of the instruments above mentioned has been followed by extensive necrosis. These facts are stated in order to warn surgeons against an *injudicious* use of these instruments. Of all the operations which have been performed for the relief of caries, resection has afforded the most satisfaction. It is, however, specially adapted to the relief only of such cases as have the caries located in the joint ends of the long bones, or in certain bones of the tarsus and carpus. The caput humeri, caput femoris, the elbow and the knee-joints have been excised for caries, and generally with gratifying results when the operation has been judiciously employed. Furthermore, it becomes necessary to amputate the diseased member when the patient's life is placed in peril by the morbid process, and none of the operative procedures which have already been mentioned is adapted to the relief of the case. Phagedenic caries, when it occurs in the extremities, generally demands amputation.

Operative procedures.

I have thus sketched an outline of the disease called caries for the purpose of giving a distinct idea of the relationship which exists between it and the other affections of the bones or the membranes and tissues which enter into their formation, such affections, for example, as ostitis, periostitis, osteo-myelitis, osteo-porosis, and necrosis. I have traced this sketch for the further purpose of giving what I believe to be a correct idea of its pathology and of the principles upon which its treatment should be founded. At the same time I have not endeavored to make the description of the malady either exhaustive or even elaborate, since there is not sufficient space now at my disposal to permit the accomplishment of such a purpose.

CHAPTER FIFTH.

OF NECROSIS.

Definition of Term "Necrosis," or Dry Gangrene of Bone. — Distinction between it and Caries Necrotica, and Mephitic, or Wet Gangrene. — Mephitic Gangrene generally dependent on a Depraved State of the Whole System. — The Author has met with it frequently in Military Hospitals. — Never, however, in Connection with Hospital Gangrene. — Color of Necrosed Bone. — Etiology. — Violence. — Arrest of Nutrition. — Necrosis not a Disease, but one of its Results. — Bone is sometimes destroyed directly by Violence, without the Intervention of any other Process. — Explanation of this Form of Death. — Necrosis from Insufficient Supply of Blood, may result from either Inflammation of the Medullary or Osseous Tissue, or of the Periosteum. — Medullitis the most Frequent Cause, and the Reasons therefor. — Large Number of Illustrative Specimens in U. S. Army Medical Museum. — Effects of Destruction of Medullary Tissue by Mechanical Violence. — M. Gerdy's Opinion that Ostitis never causes Necrosis discussed, and the Author's Conclusions. — Limitation of Necrosis by Cartilage of Conjunction. — Exposure to Cold as a Cause of Necrosis. — Rheumatism, Scrofula, Syphilis, Fever, Mercury, the Fumes of Phosphorus. — Least Vascular Parts of Bones most liable to Necrosis. — Influence of Age. — Liability of Different Bones. — Necrosis in Amputated Limbs. — Annular Necrosis. — Proper Construction of the Saw. — Symptoms of Inflammatory Necrosis. — Process of Separation, Involucrum, Sequestrum, and Exfoliation. — Treatment. — Exfoliation More Rapid in Children than in Adults. — Surgical Interference not usually proper until Separation is complete. — Prof. Van Buren's Case. — Perforation of Artery by Sequestra. — Dr. Krackowizer's Case. — When Amputation is demanded. — Summary of Treatment.

By this term is meant the death of some considerable portion of bone while the rest of the body is yet alive.[1] We have stated elsewhere that necrosis is, in reality, dry gangrene of the osseous tissue. Allusion has also been made to another diseased condition of bone wherein that tissue is deprived of its vitality in masses or portions of considerable size. I mean the *wet or mephitic gangrene of bone.* The contrast in appearance between that presented by a piece of bone involved in *necrosis* and another piece of bone involved in *mephitic gangrene* is very strongly marked. The difference in appearance is even more striking than that which obtains between the wet and the dry gangrene of the soft parts. *Necrosed bone is dry, hard, white or yellowish-white in color, insensible, sonorous when struck, and comparatively inodorous. But osseous tissue invaded by mephitic gangrene is moist, more or less softened in*

Dry and wet gangrene of bone.

[1] The word *considerable* is here employed for the purpose of distinguishing necrosis from *caries necrotica.* In the last named pathological condition there is also death of bone, but the fragments are, for the most part, small, or minute in size, like grains of sand.

consistence, not unfrequently the softening is considerable, dirty gray, dirty pale-green, or dirty greenish-brown in color, and it exhales the intolerably offensive odor of rotting bone. Necrosed bone bears a strong resemblance to the bleached osseous tissue of the skeleton in appearance. Gangrenous bone (mephitic) does not present any such resemblance. We will take this opportunity to remark further, concerning mephitic gangrene of bone, that it is not unfrequently met with in military practice in connection with traumatic lesions of the osseous tissue. I have seen it occur in a case of gunshot contusion of the femur.[1] I have met with it in a case of gunshot fracture of the thigh.[2] I have seen it in other instances of compound comminuted fracture of the long bones. I have also met with it several times in the stump-bones of amputated limbs. Mephitic gangrene of the osseous tissue is often associated with pyæmia. But it is not always connected with the pyæmic condition of the system at large, for in one of my cases the post-mortem examination showed that there was neither thrombosis nor secondary abscesses in any part of the body, and the clinical history, or the symptoms developed during life, did not, in any way, favor the supposition that pyæmia was present. In all my other cases of this peculiar affection of the osseous tissue, however, there was, at the same time, pyæmia. Mephitic gangrene of bone therefore, although it does not absolutely depend for its occurrence upon pyæmia, still belongs exclusively to certain depressed conditions of the vital powers — to certain depraved states of the body at large. At all events I have never met with it in robust subjects. While I have always met with it in connection with a depraved state of the constitution wherein there was a strong putrefactive tendency, I should also state that I have never seen it in connection with hospital gangrene. The local disease with which it was always associated, according to my observations, was inflammation of the medullary tissue of the affected bone; but the relationship between them appears to me, for the most part, to have been purely accidental, and the real cause of this peculiar rot of the osseous tissue should be sought for elsewhere, and generally in a depraved condition of the whole body, but more especially of its circulating fluids. I have never seen a case of this peculiar affection of the osseous tissue in civil practice, but at the same time, I do not know any good reason why it may not sometimes occur in civil as well as

[1] Vide *American Journal of the Medical Sciences*, July, 1865, pp. 31, 32.
[2] Vide *American Journal of the Medical Sciences*, April, 1865, p. 300.

in military hospitals. Thus much concerning the wet or mephitic gangrene of bone.

Color of necrosed bone.

We have already stated that necrosed bone usually has a white or a yellowish-white color. When exposed to the air, however, its color sometimes becomes brown, or even black, from causes which are not well understood. Stanley thinks this discoloration is connected in some way with the action of the atmosphere, since the necrosed bone is often brown or black only to such extent as it is uncovered. This discoloration of the necrosed bone takes place in the following manner: first, dark points or dots appear upon it; afterwards, these increase in number and coalesce, and thus the surface invaded becomes brown or black. The change of color, however, does not extend beneath the surface of the bone, except the osseous structure be very porous.[1] *The white color of necrosed bone, in general, is due to the fact that the blood has been withdrawn from its vessels.*

Etiology.

Necrosis may be produced, in the first place, *directly by violence*, and, in the second place, *by any morbid process which deprives the osseous tissue of an adequate supply of nutrient blood.* We are not acquainted with any other methods by which the production of necrosis is effected. It should, however, be distinctly stated here that, strictly speaking, necrosis itself is not a disease, since, so far as the pathological processes pertaining to its development are concerned, it is only a consequence or result of morbid action, but does not represent the morbid process itself. The term means simply that the vitality of some portion of bone has been suddenly destroyed by arresting the flow of nutrient blood in its vessels, that is, by stopping the circulation of red blood in the Haversian canals, and of white blood (liquor sanguinis or nutritive juices) in the canaliculi and lacunæ of the affected part.

Not properly a disease.

Caused directly by violence.

Concerning necrosis produced directly by violence. — In a paper on contused wounds of bone which was published in the "American Journal of the Medical Sciences" for July, 1865, the author has related two cases of necrosis that were produced directly by the stroke of gunshot projectiles.[2] In one case the cranium was the seat of the injury, in the other, the external malleolus. The author has seen several cases besides these wherein necrosis had been produced directly by violence. In most

[1] Vide Stanley, *On Diseases of the Bones*, pp. 74. Am. ed., 1849.
[2] Vide *op. cit.*, pp. 33, 34, 35, 36, 37.

of them the injury was occasioned either by spent or by glancing musket-balls. In such cases the necrosis appears to be occasioned directly by the mechanical commotion which is produced among the osseous particles themselves by the stroke of the projectile. The injured part of the bone loses its vitality at once, and becomes colorless and exsanguine. In all such cases a portion of the osseous tissue is killed outright, and nature immediately begins to prepare for its separation and removal from the living bone surrounding it. This form of necrosis may sometimes be produced by the kicks of animals, by powerful blows, and by falls from some considerable height, as well as by glancing and spent bullets, and may therefore occur in civil as well as in military practice. The necrosis and exfoliation of the circumferential laminæ of the tibia which not unfrequently follow the kicks of horses and mules in civil life, at the seat of the injury, are, for the most part, produced in this way. Sometimes in cases of compound fracture of the long bones we find that the vitality of the osseous tissue at the place of fracture has been destroyed by the operation of the same force which produced the fracture itself. The commotion produced among the osseous particles at the seat of injury, in this way, may be so great that the integrity of the lacunæ and canaliculi, and even the continuity of the Haversian canals is destroyed through some considerable space. Under such circumstances the injured osseous tissue dies immediately, because, in the first place, the particular histological structure by the aid of which all the nutritive processes in bone are performed (I mean the bone-cells), happens to be substantially destroyed, and because, in the second place, the supply of nutrient blood to the osseous tissue happens to be cut off by means of the injury done to the Haversian canals. In such cases the injury falls upon the elementary or microscopical structures, the microscopical spaces, and the microscopical tubes of the bone, and, although necrosis is produced thereby, the unaided vision cannot detect any change in the structure of the dead bone.[1]

Concerning Necrosis produced by Disease whereby the Osseous Tissue is deprived of such a Supply of Blood as is necessary to maintain its Vitality. — Necrosis occasioned by a deficient supply of blood to the osseous tissue, may be produced, first, by inflammation of the medullary tissue; second, by inflam- Caused by arrest of circulation.

[1] *Necrosis* is produced by *violence* in two ways: 1st, *Directly*, by the substantial destruction of the histological elements of the osseous tissue through the commotion among the osseous particles which it may occasion, and 2d, *Indirectly*, by the pathological processes which it may excite.

mation of the periosteum ; and third, by inflammation of the osseous tissue itself. We have already seen that central necrosis, when it occurs in the shaft of a long bone, is generally the result of disease of the marrow, that peripheral necrosis, that is necrosis of the circumferential laminæ, is frequently the consequence of disease or injury of the periosteum. If the inflamed medullary tissue becomes detached from the adjacent osseous tissue by the inflammatory process, or if the blood-vessels which pass from the vascular marrow into the osseous structure for the purpose of nourishing it become occluded by the inflammatory process, then the portion of the osseous tissue which depends for its supply of blood upon the diseased marrow seems likely to lose its vitality at once in precisely the same way that the foot undergoes dry gangrene from simultaneous occlusion of the anterior and posterior tibial arteries by emboli, unless indeed it draws a compensatory blood-supply from some other source. If the inflamed periosteum becomes detached from the bone by the inflammatory process, or if the blood-vessels which, proceeding from the periosteum, penetrate the bone for the purpose of supplying it with blood become occluded, then the portion of bone which in this way is deprived of its necessary supply of blood is liable to become at once necrosed. In this way we may have necrosis commencing at the interior of the bone and produced by osteo-myelitis on the one hand, and we may also have necrosis beginning on the exterior of the bone and produced by periostitis on the other hand. But inasmuch as the osseous tissue in the shafts of the long bones derives a much larger portion of its supply of blood from the marrow than from the periosteum, it follows that disease of the medullary tissue exerts a much more powerful influence in the production of necrosis than disease of the periosteum. On this point Mr. Phillips makes the following remarks: "When we carefully examine a long bone after a successful injection, we see that many vessels pass from the interior to the exterior, and that others take the opposite direction; that those which pass from the interior are much more numerous than those which pass from the exterior. We can have no better evidence of this fact than we may obtain from a fractured bone; if we examine it in some hours after the injury has been inflicted, we shall find that the nearer we approach to the medullary canal, the redder is its appearance. It is true that all the blood which gets to the medullary membrane [read *tissue*] arises from without, but it passes principally through those nutritive foramina which are so conspicuous in long bones. It is evident, therefore, that

Supply of blood from medulla.

the quantity of blood furnished to the bone by the periosteum is very much smaller than that which it derives from the medullary membrane [read *tissue* again] ; and that the bone, in the absence of the supply of blood which it has usually derived from the medullary membrane [*tissue*], becomes necrosed."[1]

It is for the reason above mentioned that, in cases of necrosis produced by disease of the periosteum alone, the vitality of the osseous tissue is, for the most part, not destroyed to any great depth, and the dead bone usually exfoliates in thin scales or laminæ. It is for the same reason that necrosis, when produced by disease of the medullary tissue alone, frequently involves a large part of the whole thickness of a long bone. It is for the same reason that necrosis in the shaft of a long bone is produced much more frequently by osteo-myelitis than by periostitis. In reference to this point the Army Medical Museum at Washington teaches a very important lesson. That collection is not only very rich in specimens pertaining to osseous pathology in general, but it is also very rich in specimens of necrosis. Now, a careful examination of that collection has convinced me that a very much larger number of the specimens of necrosis belonging to it have been produced by disease of the medullary tissue than by disease of the periosteum ; and from this we infer that necrosis is produced in military practice much more frequently by osteo-myelitis than by periostitis. Moreover, there is no good reason apparent why the same rule should not obtain in civil as well as in military practice. We have elsewhere pointed out how we can oftentimes determine by examining a fragment of necrosed bone whether the necrosis was produced by disease of the marrow or by disease of the periosteum.[2]

U. S. A. Medical museum.

Destructive inflammation occurring simultaneously in both the marrow and the periosteum generally results in necrosis of the whole thickness of the affected bone throughout the space occupied by the disease, that is, necrosis in totality. But, in such cases, the inflammatory process generally spreads from the marrow on one side and from the periosteum on the other to the osseous tissue itself, and we therefore find that the necrosis in totality has been preceded by an inflammation of all the tissues which enter into the composition of bone, namely, the marrow, the periosteum, and the osseous tissue itself.

[1] See *London Medical Gazette*, vol. xiii., pp. 190, 191.

[2] See also Figures 2, 3, 4, and 5, pp. 299, 388, and 389 of this Section.

Destruction of the medullary tissue by mechanical injury is not unfrequently followed by necrosis of the entire thickness of the bone which surrounds it. Boyer mentions a case confirmative of this statement: A thigh had been amputated which was very long in healing; after some time, a portion of bone, three inches in length, came away. On inquiry it was found that the surgeon who dressed it, daily sounded the wound with a probe, which penetrated into the bony canal, to assure himself of the extent of a fistulous opening, which had been produced by his own imprudence. The lesion had brought about the destruction of the marrow and subsequently of the bone in its entire thickness. I am inclined to think that, in this case, the inflammatory process was kindled in the osseous tissue itself, and that said process assisted very materially in the production of the necrosis.[1]

Destruction of medullary tissue by violence.

Again, necrosis appears, sometimes at least, to be produced by inflammation of the osseous tissue alone. It seems that, in at least occasional instances, the inflammatory process operating in bone arrests the circulation of blood in the diseased osseous tissue, and thus occasions its death. M. Gerdy, however, denies that inflammation of the bone itself ever produces necrosis.[2] But, in my opinion, M. Gerdy is mistaken. I have treated at least one case of necrosis of the ilium wherein I am confident that the death of the bone was produced, not by violence, nor by periostitis, nor by osteo-myelitis, but by ostitis alone. Mr. Stanley also relates a case of necrosis occasioned in the same way. This writer states that, during the progress of fever, necrosis of the shaft of a long bone has occurred without any evidence of inflammation in either its periosteum or its medullary tissue. He also suggests that, in such cases, the inflammation and death of the bone are phenomena analogous to the local congestions and inflammations which occur, under similar circumstances, in other organs. He says that, in a young female, necrosis of the entire shaft of the tibia occurred during the course of a fever, from which she died in about a month after its commencement. He found the substance of the tibia throughout of a deep-red color, whilst the medullary tissue was unaltered. But that the bone had perished was evident, on account of the entire separation of the periosteum from it, and on account of the lines of separation which had commenced to form between the shaft and the articular ends. Here, therefore, it was obvious that inflammation in the tissue of the

Inflammation of osseous tissue alone.

[1] See also what Mr. Phillips says, *London Medical Gazette*, vol. xiii., p. 191.

[2] Vide *Maladies des Organes du Mouvement*, p. 217. Paris, 1855.

bone had preceded its necrosis.[1] For these reasons I believe that M. Gerdy is mistaken when he asserts that inflammation of bone itself never produces necrosis.

I also believe that the inflammatory process in bone performs a much more conspicuous part in the production of necrosis than is generally supposed. I have been led to this conclusion by the following facts: First, I have seen several cases in which the marrow was extensively destroyed without the occurrence of necrosis. Ollier states that destruction and removal of the marrow in animals is not necessarily followed by necrosis of the surrounding bone. Under favorable circumstances, a new marrow is very rapidly formed, which, if the irritation continue, may further undergo the process of ossification.[2] Second, I have seen many instances in which the periosteum was extensively detached from bone without producing necrosis. In some of these cases the periosteum was also extensively destroyed. In such cases the lost portion of this membrane was reproduced. Ollier remarks concerning removal of the periosteum from bone that under favorable circumstances necrosis will not ensue, but a reproduction of true periosteum will take place.[3] Ollier also states that even the simultaneous removal of both periosteum and marrow in animals will not always give rise to necrosis. Third, according to my own experience in cases where necrosis has occurred in consequence of inflammation of the marrow or the periosteum, inflammation of the bone tissue itself has generally been present as a secondary lesion. Now from the facts stated above I infer that, although ostitis is usually but secondary in the order of pathological events, it is in reality of primary importance in the production of necrosis. In my opinion, when either osteo-myelitis or periostitis occasions necrosis, it does so mainly by inducing secondary ostitis.

Ostitis mainly the direct cause of necrosis.

In order for inflammation of the bone tissue to produce necrosis it must generally be acute in character. When, however, the marrow or the periosteum is extensively diseased, detached, or destroyed, it is probable that a grade of ostitis of considerably less severity will cause necrosis, than when those structures are sound.

With regard to the method in which ostitis occasions necrosis, we have elsewhere stated that it does it by arresting the circulation of blood in the affected part of bone. The products of the inflammatory process tend to produce local swelling, and may completely occlude the capillary blood-vessels by compressing them

[1] See Stanley *On Diseases of the Bones*, p. 76. Am. ed. 1849.
[2] See *American Journal Medical Sciences, January*, 1868, p. 149. [3] *Op. cit.* p. 148.

within the unyielding walls of the Haversian canals. Ollier states that necrosis is [almost] universally the result of ostitis; the capillaries of the Haversian canals become, as it were, strangulated against the bony walls which surround them, and arrested circulation, and death of the part deprived of blood, is the consequence.[1] Necrosis occurs much more frequently in the compact than in the cancellous structure of bone because the inflammatory process can arrest the circulation much more readily in the compact than in the cancellous structure of bone. Necrosis occurring in the shaft of a long bone, even when very extensive, is apt to be limited by the cartilage of conjunction or the site thereof for two reasons: first, because the cancellous structure of the epiphysis is less favorable to the production of necrosis than the compact structure of the diaphysis, and second, because the blood-supply for each is mainly derived from a different source. I have not observed that the position of the nutrient foramen exerts any influence besides this in determining the boundaries of necrosis. These are fixed or settled principally by the extent and severity of the osseous inflammation, together with the extent and severity of the primary lesion of the marrow or the periosteum or of both structures combined according as the case may be.

Limitation at cartilage of conjunction.

Again, among the recognized causes of necrosis are exposure to cold, bathing while heated and weakened by labor or violent exercise, rheumatism, scrofula, syphilis, fever, the administration of mercury, and the fumes of phosphorus. But each of these causes occasions the death of bone by inducing either inflammation of the medullary tissue, or of the periosteum, or of the osseous tissue itself, or all of them, and thus depriving the portion of bone that becomes necrosed, of an adequate supply of nutrient blood. With respect to exposure to cold as a cause of necrosis take the following example related by Stanley: A boy was occupied many hours in drawing a truck through deep and melting snow. On the next day he had severe pain in his leg, and in a few days afterwards, suppuration ensued in the soft parts of this leg, and it became evident that the shaft of the tibia had perished. It is probable that, in this case, the periosteum, the medullary tissue, and the bone itself were all involved in the inflammatory process which arrested the circulation of blood in the bone and produced the necrosis.[2] Furthermore, it is well known that necrosis of the lower jaw is sometimes produced by mercurialization. In all such

[1] See *American Journal Medical Sciences, January*, 1868, p. 152.
[2] *On Diseases of the Bones*, p. 75.

cases the mercury procures the death of the bone by inducing either inflammation of the periosteum, or of the bone, or of the medullary tissue, but more especially the last named. At least, in two cases belonging to this category, the medullary tissue of the necrosed jaw was found to have been previously destroyed by suppurative inflammation. It is also well known that the fumes of phosphorus not unfrequently occasion necrosis of the jaw-bones. This disease, which is peculiar to persons employed in the manufacture of lucifer matches, was first described by Dr. Heyfelder in 1845. It affects the lower jaw much more frequently than the upper one, but occasionally it involves both of them at the same time. The fumes of phosphorus appear to give rise to necrosis by inducing inflammation of the bone itself together with the medullary tissue and the periosteum, but more especially the first named.

From fumes of phosphorus.

The condition of the osseous tissue in respect to vascularity appears to have some influence in the production of necrosis; for we find that the least vascular parts of a bone are more frequently affected by it than the more vascular ones. It is for this reason that the compact tissue of the shafts of the long bones is more apt to become necrosed than the spongy tissue of their epiphyses, as already mentioned.

The period of youth appears also to favor the occurrence of necrosis, especially in the long bones, and at least so far as the spontaneous forms of the disease are concerned. It is most often met with in subjects between eight and years of age, and of the male sex. One reason why young are more apt to suffer from necrosis than old persons, is probably fact that in youth the bones are still growing, and on that account require a relatively larger supply of blood to keep them alive in the adult period of life. Pathological conditions which tend embarrass the circulation of blood in the osseous tissue would therefore be more likely to destroy the vitality of that tissue under such circumstances than under an opposite condition of things. Furthermore, we have seen in another part of this Section that osteo-myelitis, which is a very frequent cause of necrosis, is preëminently a disease of youth. Here then we find another reason why spontaneous necrosis occurs for the most part in the persons of the young. With regard to the fact that necrosis is, as a general thing, spontaneously developed only during the period of youth, and prin-

Splints were then applied, and he was transferred to Washington and admitted to Armory Square Hospital, August 17th, 1864. The wounds were dressed and the limb placed in a fracture box.

The general condition of the patient was then good.

October 7. — On account of great pain the fracture-box was removed and Smith's anterior splint adjusted, which allowed the patient to rest more comfortable. Simple dressings.

November 1, 1864. — Splints were removed from leg — the wound had nearly closed, but several sinuses exist which communicate with the bone — the fractured bone had not united.

The limb was laid on a pillow and dressed twice a day with simple dressings.

March 16, 1865. — The patient could leave his bed and walk on crutches with his well leg.

April 1. — The patient first came under my charge, and upon examination by the probe the sinuses were found to communicate with dead bone; the discharge of pus was about three ounces per diem. Appetite good, as was also his general condition.

April 25. — The discharge had continued to increase, the patient was gradually growing weaker. He was put under the influence of ether and an incision nine inches in length made over the front of the tibia, when it was found that the necrosis extended to within two inches of the ankle-joint and nearly to the head of the tibia. A sequestrum nine and one half inches long was removed, also several smaller pieces. In the operation a longitudinal piece of the newly formed bone (involucrum) had to be removed. After the removal of the necrosed bone new bone was found of sufficient thickness to hold the foot in its proper position. Loss of blood during operation about two ounces. The wound was dressed with charpie and cold water.

Gave the patient stimulants and anodynes every four hours.

April 26. — The patient was very weak and had continued nausea — had no appetite and vomited all food as soon as swallowed.

Evening. — Cannot even retain brandy, which increases the nausea. Beef-tea, ℥ii., given every four hours, but it is nearly all thrown off.

April 27. — Weaker; nausea continues; champagne ℥ii., with ice every four hours. Beef-tea, ℥iv., per enema ter in die.

April 29. — Champagne and beef-tea have been continued, but the patient is fast sinking, and has had a well-marked chill. His nausea has increased to such an extent that the sight of food for other patients causes him to vomit.

April 30. — Worse in every respect.

℞ Cerii. oxalat., ℥i., divide in chart, xii. sig., one to be given when the patient feels as though he would immediately vomit.

Nine P. M. — Has taken six powders during the day, took food at noon, which was retained, has not vomited once since he took the first powder. Champagne and beef-tea continued ut ante.

May 6. — Great improvement noticed, no nausea or vomiting; discontinued powders; the wound is granulating finely, the discharge being perfectly healthy pus.

June 25. — Patient can leave his bed and sit in a chair, the cavity has nearly filled, the wound is about half the size of the incision in length, and is perfectly healthy; as the pus was perfectly healthy the wound has never been touched with water; the pus was simply removed by allowing the lint to become saturated and then removing it. He has perfect use of ankle-joint and tibialis anticus (muscle). He will in all probability have a very useful limb.

His present condition is good, and he can bear considerable weight on the diseased leg.

The operator was Dr. D. W. Bliss, Surgeon U. S. Vols. I saw the patient in Douglas Hospital, Washington, just before that hospital closed. His limb was then in a healthy condition, the wounds had nearly closed, leaving three small openings, which were prevented from closing by the great tension on the newly formed integuments.

There was a slight contraction of the tendo achillis which could be easily overcome, although every possible care had been taken to guard against that result.

In this case a new diaphysis was developed from the periosteum in precisely the same way as it was in the case of Wm. H. Marston (No. XXXV.), and by this means the deficiency created by the extraction of the necrosed shaft of the tibia was, in the end, fully supplied.

Oxalate of cerium.

It is worthy of remark that the oxalate of cerium proved singularly useful as an anti-emetic remedy in this case, and it is probable that the patient was saved by its employment. This man also had well-marked pyæmic symptoms.

Concerning Necrosis occurring in the Stumps of Amputated Limbs. — It has already been stated while speaking of chronic osteo-myelitis that said disease frequently occasions necrosis of stump-bones. With regard to the inflammation of the medullary tissue itself, which in the end produces the death of the bone in such cases, Mr. Phillips thought that it was oftentimes produced by the tearing action of the saw upon it while dividing the bone in the performance of the operation. He makes the following interesting observations: —

Injury inflicted by the saw in amputation.

"I believe the affection to be produced by the violence offered to this membrane (*i. e.* the medullary tissue) by the saw. Would not the tearing action of the saw excite inflammation in any membrane? It is therefore important to know whether there is

any method of avoiding this formidable accident. It is not sufficiently borne in mind, that the medullary tissue is extremely sensible, and very easily inflamed. Bichat believed that the most acute pain which is experienced in amputation is produced by the action of the saw upon it. I do not think he was right there. In amputation the pain caused by the incision of the skin, and of the soft parts, is so intense, that the less considerable pain experienced by a lesion of the medullary tissue which succeeds so immediately to the former, is scarcely felt. But if we suspend an operation after the section of the soft parts, to proceed with it when this first impression is, to a certain extent, dissipated, the sensation is acutely perceived, and piercing cries are uttered." [1]

But this is not the only way in which the sawing of the bone produces necrosis. Take, for example, the *annular* variety of *necrosis* which is so frequently met with at the end of stump-bones. It has seemed to me highly probable that, in many cases, this form of necrosis was occasioned directly by the action of the saw upon the osseous tissue itself. In my opinion there is good reason to believe that injury of the osseous tissue inflicted directly by lacerating, contusing, and jarring or concussing it with coarse saws while dividing the bone in amputating a limb, not unfrequently produces annular necrosis. We say then that the sawing of a bone while amputating or resecting, may produce necrosis, in the first place, through injury done directly to the histological elements of the osseous tissue, by lacerating, contusing, and jarring, or concussing them, to such extent as to destroy their vitality outright through a certain space at the sawn end of the bone, without the intervention of any pathological process whatever. The sawing of a bone may, in the second place, produce necrosis indirectly by inducing destructive inflammation of the medullary tissue, together with inflammation, either secondary or cotemporaneous, but generally the former, of a corresponding portion of bone. The periosteum does not appear to be specially prone to take on inflammatory action of a destructive tendency because of injury done to it by the saw used in the performance of amputation, and therefore we but seldom find necrosis of the stump-bones produced by the agency of this membrane alone.

Annular necrosis occasioned by mechanical injury of the osseous tissue itself through the agency of the saw is met with much more

[1] See *London Medical Gazette*, vol. xiii., p. 103. Concerning the sensibility of the medullary tissue, Ollier remarks, that "the marrow, unlike the periosteum, is exceedingly sensitive to pain; its sensibility increases in proportion to the nearness of the source of irritation to the nutritious foramen of the containing bone." See *American Journal Medical Sciences* for January, 1868, p. 148.

frequently where the structure of the bone is dense and hard, than where it is soft and spongy. It is often seen when the compact tissue of the shaft of a long bone has been sawed through in performing an operation. It is but seldom seen when the division has taken place through the cancellous tissue of the epiphysis. I do not now recollect a single case of this variety of necrosis that occurred when in performing the amputation the bone was divided through its cancellous portion, and sawed easily on that account. We here find the reason why exfoliation of dead bone gives trouble to the patient and the surgeon so seldom after Syme's amputation at the ankle, wherein the sawing of the tibia takes place in the spongy structure of its inferior epiphysis; also, after amputation of the leg performed at the place of election, and amputation of the thigh, performed low down in its inferior third, through the cancellous tissue of its inferior epyphisis. But amputation when performed through the compact tissue of the shafts of the long bones is frequently followed by annular necrosis of a traumatic origin, as already stated.

It therefore becomes a matter of considerable importance to diminish as much as possible the amount of injury of the osseous tissue which may be inflicted by the saw during the performance of such operations as amputation and resection, especially if it be necessary to divide the compact tissue of the shaft of either the femur or the tibia. Now, the amount of such mechanical injury of the bone by sawing can be diminished a good deal by employing an instrument having fine, delicate, sharp teeth, and by using it with light, long, and steady strokes, instead of heavy, short, and jerking ones. And, when we consider the amount of physical suffering which is not unfrequently produced by annular necrosis, when we also consider the danger to life which it produces in occasional instances, we see at once that it is a matter of no small importance in a practical point of view. We see also that it is the duty of the surgeon to obviate its occurrence by every means in his power. The operation of amputation should be performed not only *cite, tute, et jucunde*, but such kind of a saw should be provided, and it should be used in such a manner as will inflict the least possible amount of mechanical injury upon the osseous structures while dividing them.

The amputative saw. Its construction, etc.

Symptoms of Inflammatory Necrosis. — The symptoms that attend the production of necrosis are in the early stages generally those which belong especially to the osteo-myelitis, the ostitis, and

the periostitis respectively, that deprive the osseous tissue of an adequate supply of blood and thus destroy its vitality. For an account of the symptoms belonging to the first stage of necrosis the reader is therefore referred to the discussion of each of the above-mentioned disorders, which is contained in the foregoing pages. After the bone is necrosed it becomes to all intents and purposes a foreign body, and, as such, produces irritation of an inflammatory character in the living tissues which happen to lie in relation with it. In this way abscesses are often produced in the surrounding soft parts, and, not unfrequently, a succession of them. On opening such abscesses and evacuating their contents it will generally be found by making explorations with a probe that they communicate with dead bone. In such cases the abscesses after the evacuation of their contents do not, for the most part, close up completely, but they are followed by fistulous channels, through which, if sufficient care be employed, a probe can generally be introduced sufficiently far to disclose the presence of dead bone lying at the bottom of them. In some instances small fragments of necrosed bone are, from time to time, discharged through these fistulous channels. If the necrosis be situated in the shaft of a long bone the periosteum speedily becomes thickened, reddened, and separated from the dead bone, and its proliferating or osteogenetic layer, excited to formative activity by proximity to the dead bone, proceeds without delay to produce a new osseous structure, which is destined in the end to supply the place of the necrosed part. In this way when the necrosis involves the whole thickness of the shaft of a long bone, the dead portion becomes surrounded by or inclosed within a case of new osseous tissue which is technically called an *involucrum*, and is usually perforated by a number of holes, called *cloacæ*, through which purulent matter is discharged. Through these cloacæ the necrosed bone can generally be felt without much difficulty with a probe.

Involucrum.

The process by which the dead becomes separated from the living bone is exceedingly interesting and beautiful. The living osseous tissue where it borders upon the dead becomes transformed into red medullary or granulation tissue in the following manner: The necrosed bone, having by its death become a foreign body, acts as an irritant upon the adjoining osseous tissue that is still alive. In consequence of such irritation the intercellular or basis substance of the portion of the osseous tissue that is immediately irritated, parts with its calcareous

Process of separation.

salts and undergoes softening. While this metamorphosis is taking place the bone-corpuscles become transformed into marrow cells, and when the metamorphosis is completed the dead is separated from the living bone by a layer of red medullary or granulation tissue which has been formed at the expense of the living osseous tissue itself (medullization). It is for this reason that when we examine dry specimens of necrosis we always find the necrosed portion smaller in size than the cavity in the living bone from which it has been taken. As soon as the dead is completely separated from the living bone by a layer of soft red granulations only, it is generally said to be detached. If at the same time it is encased by an *involucrum*, it is technically called a *sequestrum*. If the necrosed osseous tissue is not inclosed by an involucrum, it is called an *exfoliation* as soon as it becomes detached from the living osseous tissue.

Sequestrum and exfoliation.

Ollier, however, has drawn an important distinction between the separation and the detachment of sequestra. He defines *sequestrum* as a portion of bone separated, but not necessarily entirely dead nor completely detached; in fact, as he remarks, the majority of sequestra extracted by surgeons are vascular in at least a portion of their extent. It is by the process of absorption or medullization, which continues in this still vascular and living portion, that sequestra are finally spontaneously separated from the bones to which they have been attached. Bone that is actually dead is not changed by contact with the living tissues. On this point Ollier confirms the views of Mr. Gulliver, published in the "Medico-chirurgical Transactions" for 1838.[1] Now that my attention is freshly called to the subject I see no reason to doubt that the views expressed by Ollier on the separation and detachment of sequestra are in the main correct. The detachment does not become complete until all vascular connection is destroyed.

Separation and detachment not identical.

In cases of central necrosis occurring spontaneously, or in cases where the continuity of the diseased bone is preserved, the symptoms sometimes bear a strong resemblance to those produced by chronic abscess of the bone. There is ordinarily pain located deeply in the bone, suppuration occurs in the cancellous tissue adjacent to the necrosed portion, and, after a time, a fistulous passage is formed through the walls of the bone, by means of which the purulent matter escapes from the interior.

[1] See *American Journal Medical Sciences* for January, 1868, p. 152.

Treatment of Necrosis. — Since the sufferings of the patient and the danger to life in cases of necrosis are, for the most part, occasioned directly by the dead bone acting as a foreign body, and thus irritating the living tissues that surround it, the leading point to be aimed at in the treatment of such cases is the removal of the dead bone itself from the body. The collections of purulent matter which, from time to time, may form in the soft parts which surround the diseased bone, should always be freely incised at an early period. If the patient is tortured with pain anodynes should be prescribed for the purpose of relieving it. If his general health fails, if he loses flesh and color and strength, tonics such as the preparations of bark and iron, together with cod-liver oil, should be administered. A nourishing diet should also be allowed. The object to be attained by such a plan of treatment is to support and preserve the patient until the dead has become separated from the living bone. Not unfrequently it must be continued for a long time, on account of the extreme slowness with which the process of detaching the necrosed bone takes place. Concerning the separation of the dead from the living bone it should be observed that it is always a tedious process. However, much less time is required for its completion when it occurs in children than when it occurs in adults. Furthermore, it advances considerably more rapidly when the necrosis is situated in the bones of the upper extremities and the cranium and face, than when it involves the bones of the lower extremities. The process of detaching the dead from the living osseous tissue is also less tedious when it occurs in bones having a spongy structure, than it is in those having a compact formation, or those which consist principally of compact tissue.

Separation slower in certain bones and at certain periods of life.

But the necrosed bone should generally be extracted by the surgeon as soon as its separation is complete. I am not acquainted with any other class of surgical cases wherein surgical interference for the purpose of extracting the bone that is dead and loose is so uniformly productive of speedy benefit. Even when the necrosed fragment is not imprisoned within a shell of new bone (involucrum), but is an exfoliation, properly so called, a long time may be required to effect its discharge, if left to the unaided powers of nature, especially if it be deeply covered with soft parts, as, for example, in the thigh. In such cases the surgeon should proceed to extract the necrosed bone by operation as soon as he finds it to be loose and separated from the living bone; and to accomplish such a result he should not hesitate to make any incisions into the soft parts

that may be necessary to obtain sufficient room to apply a necrosis or other suitable forceps and take it away.

Do not operate until separation is complete.

But the surgeon should not, as a general thing, make any effort to extract the dead bone until its separation has become complete. If he operates too early he may do not a little harm to his patient. If he endeavors to remove the necrosed bone before it is detached, he may inflict such injury upon the living bone as to cause a fresh ostitis and necrosis of a fresh portion and thus may even place his patient's life in great peril. But after the separation is complete the extraction of the dead bone should not be delayed except there is some good reason for so doing.

When the necrosed fragment is imprisoned within a case of new bone (involucrum), and is what is known in surgical language as a *sequestrum*, recovery cannot, in general, take place without the assistance of surgical art. The reason is obvious. An exfoliating portion of necrosed bone, even when considerable in size, may, after the lapse of much time and the endurance of a good deal of suffering, be finally brought to the surface and discharged by the unaided powers of nature. Not so, however, with a sequestrum. It cannot be discharged until an aperture of sufficient size to permit its removal has been made in the new osseous shell which surrounds it. To perform such a task the unaided powers of nature are seldom adequate; and hence it is that patients who are afflicted with this variety of necrosis but seldom recover unless the surgeon cuts down upon the involucrum, and by means of the trephine, together with the cutting forceps, the mallet, and the gouge, makes an aperture in it sufficiently large to permit him to extract the sequestrum with a necrosis forceps. If the fragment of necrosed bone is a long one it will be necessary for him to make a long mortise-shaped opening in the involucrum, and perhaps also to divide the dead bone with a forceps or a chain saw in order to facilitate its extraction.

The following case, which occurred in the public practice of Professor Van Buren, affords a good illustration of the only plan of treatment by which the surgeon can cure a case of necrosis wherein the dead bone is invaginated by an involucrum. The account of the case also gives a good idea of the symptomatology of this variety of necrosis.

Case LVIII.— *Extensive Necrosis of Left Femur, produced by bathing while heated; Sequestrum extracted at the N. Y. Hospital by an Oper-*

ation performed by Professor Wm. H. Van Buren; Recovery. — William Limburgh, a farm laborer, from Dutchess County, aged 19, admitted to the New York Hospital, April 26th, was attacked, about four years previously, by a painful inflammation of the lower part of his left thigh, following a sudden check of perspiration by bathing when heated, which confined him to bed for several weeks, and terminated by suppuration and ulceration, leaving two sinuses near the popliteal space, through both of which, at the time of his admission, bare bone could be felt with the probe. His general health, at this time, was good, the lower third of the affected femur about double its normal size, and he suffered little pain from the disease, except after active exercise, when it became inflamed, and the discharge from the sinuses increased. In this condition, unable to do his share of labor on the farm, he applied for relief. His disease was recognized as necrosis of the femur, in which, in consequence of an attack of acute inflammation of the shaft of the bone, a portion of it had died, forming what is known as a *sequestrum*, and at the same time, apparently, the conservative energies of the system, in order to preserve the functions of the limb, had thrown around this sequestrum a shell of new bone, continuous with the portion of the femur which had remained sound. The presence of this sequestrum, then, in the interior of the newly formed shaft — technically known as involucrum — keeping up the discharge from the sinuses, constituted his disease, and the operation which we performed for its cure, consisted in exposing the involucrum by a free incision on the outer side of the thigh, some six inches in length, opening its cavity largely by several applications of the trephine assisted by the mallet and gouge, and withdrawing, through the opening thus made, a large and characteristic sequestrum, nearly six inches in length, and involving pretty much the whole diameter of the original shaft of the femur. The cavity from which it was taken was lined by a soft pulpy membrane, which communicated a velvety feel to the finger. The limb, after the operation, was placed upon a double-inclined plane, so as to secure the escape of its contents by a depending outlet, and the external wound was left open. The patient did not have an unpleasant symptom.

Dr. Van Buren's case.

Now, this is a typical case of a not uncommon disease, occurring in young subjects, chiefly males, from the age of 8 to 20, and generally from a similar cause, namely, sudden chilling when heated, such as lying on the ground, or bathing, immediately after violent exercise. Acute inflammation of a bone, and generally one of the long bones, takes place, characterized by intense, deep-seated pain in the part, and severe constitutional symptoms, such as fever, and sometimes delirium. The bones are at this period of life exceedingly vascular, their development being yet incomplete, and those belonging to the locomotive apparatus — the long bones — being most actively employed

Vascularity of young bones.

are most liable to become the seat of trouble. The bone affected dies at once, but nature almost simultaneously sets about repairing the loss, by throwing a new shaft of bone around the portion which has died, in order to save the limb, but this newly formed bone (the involucrum) often incloses the dead portion (the sequestrum) so perfectly, that it cannot be separated and thrown off by the unaided efforts of nature, and here is the opportunity for the interference of intelligent surgery. Cases of this kind often remain uncured for years for the want of an operation similar to that performed in this case. The idea is prevalent that they can be safely left to nature, but this is incorrect; it is the surgeon's duty, in such cases, to advise an operation, and I will tell you why. A sequestrum such as this, tends, under the influence of gravity, and the constant motions of the limbs, to travel downwards, and to endanger, by its change of position, the integrity of the popliteal artery, and also of the knee-joint, by penetrating them with its sharp points, which are exceedingly liable to cause ulceration. I know of the case of a medical student who lost his life by hemorrhage from perforation of his popliteal artery by a sequestrum similar to the one belonging to this case. Amputation of the thigh was resorted to in the end, but too late, and he died exhausted. In a somewhat similar instance of necrosis, which occurred under my care in this hospital, the knee-joint was perforated by a sequestrum, and it was only by prompt amputation, above the knee, that the patient's life was saved.

Perforation of artery by sequestrum.

Moreover, the limb affected by necrosis is often useless, always a source of annoyance, and liable to frequently recurring attacks of inflammation, and the sequestrum, as a rule, cannot escape without assistance. Add to this that the operation is free from danger, when judiciously performed, and almost always successful, as in this case, and I think you will agree with me that it should be advised. Since the use of anæsthetics in surgery, operations for necrosis are much more common than formerly.[1]

The author, recognizing the soundness of the advice which it presents, has taken the liberty to italicize the last paragraph.

In cases of necrosis such as those related by Professor Van Buren it is obviously the duty of the surgeon to extract the sequestrum as soon after its detachment as the patient gets into a fit condition to endure the operation. The performance of the operation in such cases should never be unnecessarily delayed, for, if that be done, the patient's life is placed in unnecessary peril, and the surgeon who does it becomes guilty of a sad omission in the discharge of professional duty.

[1] See Professor Van Buren's Clinical Lecture, delivered at the N. Y. Hospital, and reported in the *American Medical Times*, 1860, vol. i. p. 19.

The following case affords another illustration of the method of treatment generally required by cases of necrosis. It also presents judicious advice with regard to the period during which it is the duty of the surgeon to extract the dead bone by operation. It is probable, however, that the operation might have been performed at an earlier date with equal advantage to the patient.

CASE LIX. *Necrosis of the Tibia in a Boy of Seven Years produced by Inflammation of the Medullary Tissue; Dead Bone extracted by Operation; Recovery.* — Dr. Krackowizer presented to the New York Pathological Society, September 25, 1861, specimens of necrosed bone, and remarked that they were of interest, as illustrating a point in operative surgery, in reference to the time during which the operation should be performed. He thought a good deal of harm could be done by operating too early, and an equal amount of mischief by postponement. The proper time to choose for such a proceeding was, as in the specimen presented, when the sequestrum was merely imbedded in the soft granulations which sprouted out of the involucrum. Dr. Krackowizer's case.

The patient was a boy seven years of age, who, two years ago, was seized with symptoms of *ostitis in the medullary canal*[1] of the right tibia, which, in time, formed an abscess, discharging from the front of the tibia by means of several sinuses. Through each of the openings a probe being passed struck dead bone. An operation was advised and accordingly performed. A T-shaped incision was made on the anterior part of the tibia, and the flaps were dissected up, exposing the involucrum, which was formed of the compact tissue of the tibia. This was removed. There were two or three cloacæ on the outer aspect of the limb, which, on account of the thickness of the bone between them, were united by means of Heine's osteotome, an exceedingly useful instrument for such purposes. The cavity of the involucrum, being exposed, was found to be filled with velvet-like granulations, over which were scattered pieces of sequestrum, which could be lifted out with the greatest ease. The boy, since the operation, has done remarkably well, the wound being nearly filled up with granulations.[2]

In a large majority of the cases of necrosis the operative procedures which we have described are sufficient to effect a cure of the disease and preserve a useful limb for the patient. There are, however, some cases in which the extraction of the sequestrum alone will not suffice to relieve the malady, and the amputation of the diseased member is then demanded in order to save the patient's life, or to place him in a condition of com- Cases demanding amputation.

[1] I do not understand what this phrase means unless it is *inflammation of the medullary tissue*, etc.

[2] Vide *American Medical Times*, 1861, vol. iii. p. 242.

parative comfort. If the sharp end of the sequestrum pierces an important artery, or penetrates the cavity of one of the great articulations, as it did in the instances referred to by Prof. Van Buren, it becomes necessary to amputate on the spot in order to save the patient.

Again, it may be advisable to amputate the diseased member in occasional instances where the involucrum is so large or thick as to render the limb unwieldy, and unfit for useful purposes on that account. In such case the affected limb is generally much tumefied by reason of the great size of the new osseous formation, and, at the same time, the skin covering it is very tense, and liable to become the seat of ulcerations which are difficult if not impossible to heal. I have treated one such case. The disease involved the leg and followed compound comminuted (gunshot) fracture. Amputation at the place of election was employed as a remedy of last resort. The patient made an excellent recovery.

Central necrosis from fracture.

Central necrosis following fracture also, sometimes, demands amputation. The symptoms produced by this affection not unfrequently bear a strong resemblance to those occasioned by chronic abscess of bone. The pain is very great; and it occasionally happens in such cases that the patient, after enduring untold suffering for a long time, becomes so much exhausted that it is necessary to amputate the diseased member in order to save his life. Mr. Holmes refers to a case of central necrosis following fracture wherein it became necessary to amputate the limb thirty-five years after the occurrence of the original injury.

Reamputation.

Furthermore, in cases of necrosed stump-bones, it is sometimes necessary to reamputate on account of a diseased condition of the osseous tissue which has grown out of the irritation excited in it by the dead bone. The next case furnishes an instance wherein such a proceeding had to be adopted. I believe that in such cases, generally, the pathological condition of the osseous tissue which has been produced by prolonged contact with dead bone, is that to which the term *caries* and *osteo-porosis* has been applied.

Case LX. *Reamputation for Necrosis of a Stump-bone (Arm); Recovery;* contributed by Prof. E. Andrews of Chicago. — Henry Brady, Co. G, 6th Wisconsin Infantry, was shot through the elbow at the battle of Antietam. The arm was amputated at its lower third. The stump-bone became necrosed. Two years afterwards I reamputated the stump in the middle to get rid of the diseased bone. The patient recovered.

We may state, in conclusion, that the leading points in the treatment of necrosis, are to preserve and build up the patient's strength by suitable medication and alimentation, to extract the dead bone as soon as it is completely detached, and, in occasional instances, to amputate the diseased member. Summary of treatment.

END OF SECTION SECOND.

SECTION THIRD.

ON PYÆMIA.

PYÆMIA.[1]

Application of the Term Pyæmia. — Not synonymous with Septæmia, but only a Variety. — Conditions preceding. — Period of Accession. — Subsequent to Local Suppuration. — Has Special Relations to Suppuration. — Sanitary Condition of Hospitals in which it has occurred. — Piorry's Theory of Pus Corpuscles in the Blood not sustained. — Boerhaave's Opinion that the Open Mouths of Wounded or Ulcerated Veins may absorb Pus not confirmed by Actual Observation. — Spontaneous Disappearance of Pus from Cavities explained. — Lymphatics cannot absorb Pus. — Objection to Mr. Simons' Experiments and Conclusions. — Sedillot's and Lee's Experiments defective. — Clinical History of Pyæmia. — Division into Acute and Chronic. — Cases illustrating Acute Pyæmia in Connection with Injuries of the Bones. — Cases illustrating Chronic Pyæmia in Connection with Similar Injuries. — Symptoms of Pyæmia. — Illustrative Cases. — Diagnosis. — Points of Resemblance with Malarial Fever and Typhoid Surgical Fever. — Differential Diagnosis. — Prognosis. — Ninety-five per cent. died at Stanton U. S. General Hospital. — Cases in which Recovery took Place reported. — Causes and Relations of Pyæmia. — Not an Idiopathic Affection. — Relations to Injuries of the Bones and especially to Injuries of the Cancellous Structure, and to Osteo-myelitis. — To Inflammation of the Absorbents. — To Injuries of the Blood-vessels. — Of the Skin. — Of the Muscular and Connective Tissues. — Non-traumatic Pyæmia following Camp-fever. — Pyothorax. — Enlargement of the Spleen. — Predisposing Causes. — Influence of Age. — Efficient Cause. — Putrefaction of Blood-clots, Gangrene, etc. — Evidences of Zymotic Origin. — Pathological Anatomy of Pyæmia. — Dr. Bartholow's Post-mortem Observations. — Treatment. — Dr. Leale's Cases. — Prophylaxis.

THIS term is here employed, not in accordance with its literal signification, but as a symbol to represent a peculiar morbid or rather poisoned condition of the blood and system at large, which often follows the infliction of wounds or other forms of injury, and the performance of surgical operations, appearing in that connection, for the most part, not until the lapse of some time after the establishment of local suppuration. It is also attended with the development of a striking and peculiar train of symptoms, together with certain anatomical lesions that are oftentimes highly characteristic of the pathological process in question. It almost always proves fatal, and, in a large majority of instances, terminates speedily in that way. For example; during the year ending September 30, 1864, *fifty-nine* cases of undoubted pyæmia, in the sense expressed above, were treated in the Stanton

Generally fatal.

[1] We do not consider the term *pyæmia* as synonymous with *septæmia*, since the latter represents several varieties of septic blood-poisoning besides that which is connected with some local suppuration as a primary focus of infection. We do, however, consider that pyæmia is a variety of septæmia. See chapter on Consecutive Gangrene in Section First; also pp. 404, 408, in Section Second. At the latter place this point, *i. e.*, the difference between *pyæmia* and *septæmia*, is fully discussed, and the reader's attention is respectfully called to it in this connection.

U. S. Army General Hospital, of which the author then had charge. Of these cases, *fifty-six* died, and but *three* recovered, and thus a ratio of mortality of almost 95 per cent. was afforded. In *fifty-one* of the fifty-six fatal cases it is stated how long the patient lived after the appearance of pyæmia. By analyzing them we find that *two* patients survived the onset of the disease less than 2 days, that *two* cases lived 2 days, *two* 3 days, *four* 4 days, *four* 5 days, *five* 6 days, *nine* 7 days, *five* 8 days, *three* 9 days, *four* 11 days, *one* 12 days, *two* 13 days, *two* 15 days, *two* 16 days, *two* 18 days, *one* 21, and *one* 38 days. Thus, it is shown that of these 51 fatal cases 36 survived the pyæmic attack less than 10 days, and only 15 lived for a longer period. Two of these patients died between 24 and 48 hours after they were attacked with pyæmia, while *one* survived its occurrence for thirty-eight days.

How long survived.

Of these *fifty-nine* cases of pyæmia which were treated in Stanton U. S. Army General Hospital between October 1st, 1863, and September 30th, 1864, inclusive, the record further states that in *fifty-seven* cases the disease supervened during the after treatment of either gunshot injuries or surgical operations performed for such injuries, that in *one* case it appeared as a sequel of typho-malarial or camp-fever and empyema, and that in the remaining case it occurred in connection with a preëxisting abscess of the thigh.

Upon what supervened.

By making a further analysis of the *fifty-seven* cases having a traumatic origin, we find that in *one* instance pyæmia appeared on the 3d day after the performance of secondary amputation of the thigh for gunshot fracture of the femur inflicted sixteen days previously, that in *four* cases pyæmia supervened on the 4th day after wounds from gunshot projectiles or amputations for such wounds, in *two* cases on the 5th day, in *two* cases on the 6th day, in *one* case on the 8th day, in *two* cases on the 9th day, in *five* cases on the 10th day, in *one* case on the 11th day, in *two* cases on the 12th day, in *one* case on the 13th day, in *four* cases on the 14th day, in *two* cases on the 15th day, in *two* cases on the 16th day, in *one* case on the 17th day, in *five* cases on the 18th day, in *three* cases on the 19th day, in *one* case on the 20th day, in *two* cases on the 21st day, in *two* cases on the 23d day, in *one* case on the 25th day, in *one* case on the 28th day, in *one* case on the 31st day, in *one* case on the 37th day, in *one* case on the 38th day, in *one* case on the 43d day, in *one* case on the 46th day, in *one* case on the 90th day, and in *six* cases the duration of the in-

Period of accession.

terval between the occurrence of the traumatic lesion and the appearance of pyæmia is not stated.

By arranging them in groups we find that 17 cases occurred on or before the 10th day after injury or operation, that 22 cases occurred between the 11th and 20th days inclusive, that 6 cases occurred between the 21st and 30th days inclusive, that 3 cases occurred between the 31st and 40th days inclusive, that 2 cases occurred between the 41st and 50th days inclusive, and that in *one* instance pyæmia appeared as late as the 90th day after the accident. It is also worthy of remark that in 43 cases pyæmia supervened on or before the 23d day, and in only 8 cases did it appear at a later date. The foregoing statistics seem to warrant us in stating that traumatic pyæmia belongs especially to the period which is embraced between the fourth and twenty-third days subsequent to the infliction of the injury or the performance of the surgical operation, that it occurs but comparatively seldom after the twenty-third day, and that if a patient suffering from a gunshot wound or an amputation reaches the twenty-fourth day afterwards in safety, the risk of a fatal result from pyæmia is but small, provided the treatment continues to be judiciously conducted, and the hygienic conditions are favorable.

Subsequent to local suppuration.

Again, it is worthy of special remark that in none of the foregoing cases did pyæmia make its appearance previous to the establishment of local suppuration.[1] Even in the case where it supervened on the third day after secondary amputation of the thigh for gunshot fracture, the wounded limb was already suppurating freely, and the ends of the broken bone were found bathed in unhealthy purulent matter at the time of the operation. He died on the fourth day after the pyæmic invasion, and on examining the stump-bone at the autopsy its medullary tissue was found to be the seat of a suppurative inflammation (suppurative osteo-myelitis). In the two non-traumatic cases which we have mentioned, the development of pyæmia was preceded in one of them by empyema and in the other by abscess of the thigh.

Condition of hospitals.

With regard to the sanitary condition of the hospital in which these cases of pyæmia were observed, it should be stated that it was entirely free from hospital gangrene, that,

[1] We believe that pyæmia is the variety of septæmia in which some local suppuration constitutes the primary focus or source of infection. In the other varieties of septic blood-poisoning the source or focus from which the poison proceeds, and the symptoms, or secondary disturbances and structural lesions induced by it in distant organs, are of quite a different nature, as, for example, we may see in cases of dissection wound, gangrene from injury of blood-vessels, senile gangrene, spreading inflammatory gangrene, and hospital gangrene.

notwithstanding the broken-down and cachectic condition of many of the patients admitted to its wards, a case of erysipelas was but very seldom seen to originate therein, that it was never overcrowded with patients, that it was thoroughly ventilated, that it was constantly kept as clean as possible, and that the most approved disinfectants were freely and habitually used in all parts of the institution.

We have already stated our purpose to employ the term *pyæmia* or *pyohæmia* not in accordance with its literal signification, and we will next proceed to give our reasons for so doing. This term, derived from two Greek words, πῦον, *pus*, and αἷμα, *blood*, signifies literally purulent or pus-bearing blood, and was coined by Piorry, because he supposed that the disease which it represents consists essentially of an admixture of pus with the current of the circulating blood. Now, the commingling of purulent matter, as such, with the blood, necessarily involves the commingling of the morphological constituents of purulent matter with that fluid, and hence the admixture of pus-corpuscles with the blood. If, then, Piorry's assumption be correct, pus-corpuscles should always be present in the blood of persons affected with the so-called pyæmia, and their presence should be demonstrated therein provided the pyæmic blood is subjected to a sufficiently thorough and exact examination with the microscope. But has any such demonstration of the constant, or even the frequent, presence of pus-corpuscles in the blood of patients laboring under the so-called pyæmia, ever been satisfactorily made? If so, what observer has made such demonstration, and what other observer has verified that demonstration?

Piorry's theory of causation. Pus in the blood.

It has, indeed, been thought by some who advocate the views of Piorry that they have found pus-corpuscles in large quantity in the so-called pyæmic blood, but subsequent investigation has shown that what they took to be pus-corpuscles was, in all probability, made up entirely of the colorless corpuscles of the normal blood, which coincidently were present in excessive quantity. They saw not pus-corpuscles in the blood, but the colorless blood-cells, which are so like pus-corpuscles as easily to be mistaken for them, so that if in any specimen we meet with such elements, we can never say with certainty off-hand whether we have to deal with colorless blood or pus-corpuscles (Virchow). We therefore object to the employment of the term pyæmia according to its literal meaning, in the first place, because

Colorless blood-cells mistaken for pus.

it has not been satisfactorily shown that the so-called pyæmic blood is characterized by the presence of pus-corpuscles in it.

We object to its employment in that sense, in the second place, because the statements concerning the method by which purulent matter *per se*, and consequently pus-corpuscles, are introduced into the current of the circulating blood, do not bear the test of even a gentle criticism. With regard to the statement that suppurative phlebitis oftentimes furnishes an occasion for the introduction of pus into the blood, it should be remembered that the more exact and thorough investigations into the phenomena of the so-called suppurative phlebitis which have been made during a recent period have abundantly proved, that what were formerly believed to be collections of purulent matter that had been formed within the canal of veins by a process of secretion from the internal surface of their lining membrane, do not, in reality, consist of purulent matter at all in a very large majority of instances, but of a liquid substance having considerable resemblance to pus, and therefore called *puriform* matter by some, which has been produced, not by the inflammatory process, but by the spontaneous softening or retrograde metamorphosis of coagulated blood, called technically *thrombus*, with which the vein supposed to be inflamed has become more or less completely filled through the operation of causes which, for the most part, are not inflammatory in their nature: or, in other words, it has been found that the morbid condition of the veins, which was supposed by John Hunter, Cruveilhier, and others to be a suppurative inflammation of their lining membrane, is not, in general, an inflammatory condition at all, that the *puriform* matter which is often found within the veins in such cases is not pus, nor is it even a product of the inflammatory process, but it is formed by the spontaneous degeneration of the coagulated blood held within the walls of *thrombosed* veins, which is effected by the operation of forces that are purely chemical in their nature, and may be imitated by experiment outside of the human body.

Puriform matter in phlebitis.

Degeneration of thrombus.

Furthermore, it has been found that when a vein really becomes the seat of suppurative inflammation the pus is formed not within the canal of the vein, but in the connective tissue between the coats which constitute its walls, that if the inflammation lasts long enough a collection of pus in the nature of an abscess is formed in this way between the coats of the vein, that the purulent matter cannot get from such an abscess into the current of the circulating blood except by bursting through

Abscess in coats of veins.

the internal coat of the vein from without inward, or by perforating said coat from the same direction by the ulcerative process, and that when such an abscess has discharged its contents in this way into the current of the general circulation, its cavity is apt to become immediately filled up with blood, which flows out from the penetrated vessel.

Hæmatitis of Piorry not sustained.

With regard to the spontaneous production of pus in the blood itself by the operation of the inflammatory process upon the morphological constituents of that liquid, the *hæmatitis* or inflammation of the blood of Piorry, the suppuration of the blood, as it was afterwards called by some pathologists, and spontaneous pyæmia, as it was denominated by others,[1] it is only necessary to state here that this theory has been generally abandoned as untenable, since subsequent investigation showed that what had been believed to be pus-corpuscles in the blood, were in reality only colorless blood-cells, that the principal alteration in the morphological constituents of the blood in these cases consisted in a large and absolute increase in the number of these colorless cells, and that this increased quantity of the colorless blood-cells, this *leucocytosis*, was not limited in its occurrence to cases of pyæmia (so called) but was also found in connection with other diseases of an exhaustive character, for example, scrofulosis, phthisis pulmonalis, typhus and typhoid fevers, diffuse phlegmon, and cancer, and was even produced by certain purely physiological conditions, such as pregnancy. Allusion has been made in this place to the theory of the spontaneous development of pus in the blood and to the microscopical observations, both pathological and physiological, which refute it, because from time to time it has been revived under somewhat different forms, and is likely to be resurrected again hereafter.

Properly a leucocytosis.

Can pus be absorbed, or escape from an abscess into veins?

Can pus get into the current of the circulating blood from the cavity of a suppurating sac, or from the track of a suppurating wound, or from any suppurating surface, by absorption through the open mouths of wounded or ulcerated veins, as was originally stated by Boerhaave, and subsequently asserted by Ribes and Velpau? This question must be answered,

[1] In the first case of the affection now called *leukæmia* which Bennett saw he found the colorless corpuscles to be present in much larger numbers than in any instance on record, and at once inferred that it was a case of "suppuration of the blood." This conclusion of his indeed was not original, but was based upon the hæmatitis of Piorry, who had conceived the blood itself to become inflamed and thus engender pus, a state which was afterwards denominated spontaneous pyæmia by the Vienna school.

All these errors proceeded from the circumstance that an enormously great number of colorless corpuscles were found in the blood, which in turn were mistaken for pus-corpuscles. Vide Virchow's *Lectures on Cellular Pathology*, p. 223. Am. ed.

generally, in the negative, for if the orifice in the vein be large enough to allow the corpuscles of purulent matter to *enter* the vessel it is also large enough to allow the corpuscles of the blood, including both the red and the white ones, to *pass out* from the vessel, and thus in such cases the entrance of pus into the circulation is effectually prevented by the outflow of blood from the current of the circulation towards the suppurating tissue, or the suppurating wound, or the suppurating surface. It seems possible, however, for purulent matter to be admitted into open veins under favorable circumstances, in a few localities, such as the neck and axilla where the suction power of the chest is strongly felt in the veins during the inspiratory movement, but in order for it to enter the vein even then, the orifice in its walls must be held open either by the unnatural stiffness of the walls themselves or by their adhesion to some sclerosed, dense, and unyielding structure lying external to them. When we consider how seldom, speaking comparatively, a fluid so subtle as the air is admitted into the veins of the neck during surgical operations by which they are inevitably wounded, we cannot fail to perceive how very rarely indeed a liquid so gross as purulent matter is likely to get introduced, in the form of purulent matter, into these vessels, even under the most favorable circumstances. Indeed, so far as I am informed, there is no case of this kind of purulent absorption on record, and the foregoing remarks have been made because it is barely possible for pus to enter the veins in this way in the neck and armpit. But in the extremities and in all parts of the body where the suction power of the heart and of the thorax during inspiration, are not perceptible in the veins, pus cannot pass through the open mouths of these vessels and thus gain admission to, and become commingled with the circulating blood.

Pus spontaneously disappearing.

Again, when the purulent matter is removed spontaneously from the cavity of the pleura in a case of empyema, or when the contents of an abscess disappear spontaneously and it dries up, as sometimes happens in the thigh and other parts of the body, it is said by some that in such a case the pus has been absorbed into the blood, carried away in its current, and subsequently excreted from the body, through the agency of the various excretory organs. But if we examine closely into the process by which nature effects the cure of empyema and abscess we find *that pus is never absorbed in the form of pus in these cases.* The purulent matter, under such circumstances, disappears only in one of two ways.

When it disappears in the first way, the pus with its corpuscles is more or less intact at the time of the reabsorption. It is the fluid portion of the pus, the liquor puris, or the pus-serum, alone which is absorbed and carried away in the blood. The pus-corpuscles remain behind, and thus of course the matter becomes thicker in proportion as the fluid disappears. This constitutes the long known *thickening or inspissation* of pus, whereby is produced what the French term "*pus concret*," which consists of a thick mass, containing the pus-corpuscles in a shriveled condition, when not only the fluid between the pus-corpuscles (pus-serum) but a part also of that present in them has been withdrawn. This is the kind of inspissation which we see occur on a large scale in the case of imperfect reabsorption of pleuritic exudations, when very large layers of a crumbling substance remain behind in the sac of the pleura; and also round about the vertebral column in caries of the vertebræ, cold abscesses, etc. In all these cases the reabsorption is at an end as soon as the fluid has disappeared; but the solid parts remain behind and either undergo the calcareous transformation or give rise to ulceration.

Liquor puris is absorbed.

The second form of purulent reabsorption is that which constitutes the most favorable case, when the pus really disappears and no essential part of it need remain behind. But here too the pus is not reabsorbed as pus, but first undergoes a fatty metamorphosis; every single cell sets fatty particles free within it, then breaks up and at last nothing further remains than fatty granules and intervening fluid in which they are suspended. Then, therefore, there exists no longer either cells or pus; and their place is occupied by an emulsive mass, a kind of milk, composed of water, some albuminous matter and fat, and in which even the presence of sugar has on various occasions been demonstrated, whereby a still greater analogy with real milk is brought about. It is this *pathological milk* which afterwards comes to be reabsorbed — once more therefore not pus, but fat, water, and salts. These are the processes which may be denominated the "physical reabsorption of pus;" a reabsorption, in which pus is not reabsorbed as such, but either only its fluid constituents, or its solid ones after they have been considerably altered by an internal transformation.[1] So far as the veins and blood-vessels generally are concerned we are therefore justified in saying that they do not absorb pus as such, and that when pus becomes commingled with the blood through their instrumen-

Absorption after transformation into fatty granules, and "pathological milk."

Veins do not absorb true pus.

[1] Vide Virchow, *Lectures on Cellular Pathology*, pp. 212 to 217.

tality, it is only by the bursting of an abscess through their walls whereby the contents of said abscess are discharged into the current of the blood flowing through them.

The question next arises whether pus as pus does not gain admission to the circulating blood through the agency of the lymphatic vessels, the absorbents properly so called. To this question also a negative answer must be given, for the anatomical structure of the lymphatic glands is such that pus-corpuscles cannot pass through them into the trunk of the absorbent vessel beyond. The lymphatic glands perform the office of exceedingly fine filters as well as that of glandular tissue proper, and the pus-corpuscles from their size cannot get through them.[1]

Lymphatics cannot.

Upon examining these different pathological processes in this manner one by one, it is really impossible to discover anything at all, which in a morphological point of view, can justify the assumption of a condition of the blood such as might with propriety be called pyæmia in the strict acceptation of that term. In the extremely rare cases, in which pus breaks through into veins, from a phlebitic or some other very unusual form of abscess, the purulent ingredients may, without doubt, be conveyed into the circulating blood, but in such instances the introduction of the pus occurs for the most part but once. The abscess empties itself, and if it be large, an extravasation of blood is much more apt to ensue than the establishment of a persistent pyæmia, properly so-called. Perhaps, however, we shall at some future time succeed, in the course of such a process, in discovering pus-corpuscles with well defined characters in the blood; at present, however, the matter stands thus; it can most positively be maintained that nobody has hitherto succeeded in demonstrating by arguments capable of supporting even gentle criticism, the existence of a morphological pyæmia. This term, therefore, must, as designating a definite change in the blood, be entirely abandoned.[2] For this reason we stated at the outset that we do not employ the word pyæmia in accordance with its literal signification, but as a symbol to represent a peculiar pathological condition, or intoxication, of the blood and the whole system, which generally springs from some local suppuration, and is attended with the development of peculiar phenomena in the shape of symptoms and pathologico-anatomical lesions. We do not discard the term, because, in the first place, it is already in common use throughout the world, and, in the second place, we are not prepared to offer a better one.

How we propose to use the term "pyæmia."

[1] Virchow, *op. cit.* p. 217 *et seq.*

[2] Virchow, *op. cit.* pp. 228, 229.

Injection of pus into veins of lower animals.

Mr. Simon states in his sixth report as medical officer of the privy council of the British government, which was presented March 31st, 1864, that "pyæmia can be experimentally imitated in the lower animals by the injection of a little normal pus into a vein," and he proceeds to say, that "there is not, I think, any valid reason for doubting but that this kind of material infection of the blood, accidentally arising, is the essential cause of human pyæmia."[1] But let us pause a moment here and inquire whether, in cases where a little normal pus is injected into the veins of the lower animals, pyæmia is *always* or even *frequently* produced. What results have experiments of this sort, performed on the inferior animals, afforded us, not in the exceptional, but in the great majority of instances? Almost all observers coincide in stating that, when healthy pus is injected into the veins of animals with the observance of proper precautions, no symptoms are developed during life, and no pathologico-anatomical lesions are found on killing the animal and making an autopsy, which can be compared with pyæmia in man. Beck found in fourteen injections that not one was followed by symptoms of purulent infection. (Barwell.) Sédillot, the stout defender of pyæmia strictly so called, could not produce pyæmia in dogs except by repeated injections of pus, for which purpose he left an elastic catheter in the vein of the dog for several days. That the presence of a foreign body in the circulation for so long a time would give rise to coagulation of blood in the vessel, and that pieces of the thrombus thus produced, would, at a later injection, be propelled along with the pus to the heart, and subsequently become caught and impacted in one or more branches of the pulmonary artery, can hardly be doubted.[2]

Virchow has shown that most of Sédillot's experiments were vitiated by the mode in which the wound was made, and the nozzle of the injecting tube thrust in; for the blood must have formed coagula around those parts, which afterwards were carried into the circulation. Mr. H. Lee's experiments, having been performed by a similar method, are clearly open to the same sources of fallacy. Indeed, a committee appointed to repeat Mr. Lee's experiments, with a view to determine the effects of pus on the blood, obtained results widely different from those obtained by Mr. Lee. This committee made two experiments upon an ass. In the first experiment fresh and healthy pus to the extent of two ounces was in-

[1] Vide Mr. Simon's Sixth Report, pp. 60, 61. London, 1864.

[2] Vide Dr. Krackowizer's "Remarks on Pyæmia before the New York Academy of Medicine" published in the *N. Y. Medical Journal*, August, 1865, p. 367.

jected into the saphena vein; and the animal appeared not to suffer any inconvenience from it. In the second experiment two ounces of fresh and healthy pus were injected into the jugular vein of the same ass, some time after the performance of the first experiment, the animal having been perfectly well during the interval; and no bad effect was produced. The pus mixed readily with the blood and did not coagulate it. The animal presented no unusual symptoms during the next few days, when he was killed, and the parts carefully dissected. The vein was pervious, presenting no thickening, nor cording, nor abscesses, and the external wound was nearly healed.[1]

We therefore conclude, that, in the vast majority of instances, when sufficient care has been taken to select a fresh and healthy pus, and to inject it into the veins of animals by a proper method, no morbid phenomena have followed the operation; and, furthermore, that Mr. Simon's assertion (which has just been quoted), concerning the causation of pyæmia in animals and in man, is clearly shown to be not warranted by the results of the experiments upon animals that have been made by a number of different observers for the purpose of artificially producing pyæmia, especially when such experiments are taken as a whole, subjected to rigid scrutiny and careful comparison, and then repeated, with the observance of proper precautions, if any sources of error are discovered.

Generally produces no results.

Let us now depart from the region of hypothesis and conjecture, and proceed to study the *clinical* history of the disease which, for the present, we have agreed to call pyæmia, in default of a better name, as it occurs in man.

Clinical history.

Now, when we compare together or contrast the objective phenomena presented by different cases of this affection, we observe that they differ from each other very much in respect to intensity, rapidity of development, and duration. In one class of cases we find that the patient is suddenly stricken down by this disease, with symptoms of great severity, and that in the course of a very brief period, varying in duration from thirty-six hours to five or six days, he sinks and dies, notwithstanding all the assistance which the surgical art is, at present, able to afford him. In another class of cases we find that the symptoms which accompany

[1] Vide *Edinburgh Monthly Journal*, vol. vii. p. 272; also Barwell *On Diseases of the Joints*, pp. 93, 94. Am. ed.

the pyæmic invasion are much less violent, that the disease pursues its downward career with much less rapidity, and that death is not produced till after the lapse of many days or several weeks, five or six not unfrequently. Thus we have two types of the disease presented for our consideration, namely, the *acute* and the *chronic;* and we shall find it convenient for purposes of study and description to employ the terms *acute and chronic pyæmia* in these pages.

Acute and chronic forms.

The next four cases present us with examples of acute pyæmia, such as are often seen in connection with wounds and surgical operations involving bone. They occurred in the author's practice.

Four cases of acute pyæmia.

Case I. *Gunshot Fracture of Right Humerus in Middle Third; Exsection of the Fracture-splinters; Pyæmia suddenly supervened on Sixteenth Day; Death Two Days afterwards from Pyæmic Pleuro-pneumonia; Autopsy; Thrombosis of Right Axillary Vein; Secondary Abscesses in Lungs and Liver; Copious Effusion in both Pleural Cavities.* — Private Lucius J. Lewis, Co. K, 1st Michigan Cavalry, aged 27, admitted to the Stanton U. S. Army General Hospital June 4, 1864, was wounded at Old Church, Va., May 28, in the middle third of the right arm. The humerus was fractured by the projectile with extensive comminution. The wound was dilated by incision and the fragments of comminution extracted on the field. He also informed us that his general health was good at the time the injury was inflicted and the operation performed.

June 6. — Patient doing well; wounds granulating nicely; the treatment consists in the administration of nutrients, tonics, and stimulants, and the application of a weak solution of the permanganate of potassa to the wounds. He continued to do well until

June 13. — Evening. He has had a chill and unexpectedly fallen into a bad way. He has marked dyspnœa, with dark-colored, viscid sputa, but no cough. He also has irritability of the stomach.

June 14. — The vomiting continues. He complains of general debility and has great dyspnœa. Prescribed cupping, both wet and dry, of the chest, to be followed by a warm poultice covered over with oiled silk on its outer side, and a stimulating expectorant mixture with carbonate of ammonia to be administered internally.

June 15. — He is failing. The dyspnœa is greatly increased. He died in the afternoon.

He did not have any cough whatever.

The *autopsy* revealed the existence of *thrombosis of the right axillary vein*, and the presence of numerous *secondary abscesses in the liver*, varying in size from a pea to a hickory nut. There were also numerous

secondary abscesses in both lungs; and the exterior of these organs was covered with false membrane. Each pleural cavity contained a large amount of serous effusion, having a lemon-yellow color. The right contained about thirty-two ounces, and the left about sixteen ounces of such effusion. The spleen and kidneys were normal. Examination of the arm at the place of operation showed that the ends of the broken humerus had not been sawed off, but that the fragments of it in the shape of fracture-splinters had been extracted, and these in the aggregate represented about three inches of the shaft of the broken bone.

Comments. — The symptoms of pyæmia made their appearance in the foregoing case very suddenly and unexpectedly. The patient, who was a healthy young man of twenty-seven, appeared to be doing well until the day of the pyæmic attack. The disease also ran its course very rapidly, for in two days he died. The interior of the humerus was not examined at the autopsy, but, from what has been found in strictly analogous or precisely similar cases, I have no doubt that if the injured bone had been split lengthwise with a saw, its medullary tissue would have been found to be the seat of a suppurative inflammation, which had laid the foundation for the occurrence of the purulent infection, the visceral abscesses in the lungs and liver, and the pleuritic inflammation.[1]

No cough accompanied the pneumonia.

It is also worthy of remark that although the inflammatory mischief in the lungs and pleura in this case was extensive and severe, it was, from first to last, entirely unaccompanied by cough. The reflex function of the respiratory nerves appears to have been suspended, in great part, by the hebetude growing out of the sudden pyæmic intoxication, and thus it happened that the tough and dark-colored pneumonic sputa was brought up mainly by the ciliary movements of the epithelium, which lines the air passages of the chest and throat, instead of being expelled by the act of coughing.

Case II. *Acute Pyæmia produced by Gunshot Wound of Thoracic Parietes with Fracture of Eighth Rib; Death on Sixth Day of the Disease; Autopsy; Secondary Abscesses in Lungs; Bloody Serum in Left Pleural Cavity; Liver Enlarged and Fatty; Spleen Enlarged and Softened; Kidneys involved in Bright's Disease.* — John Stuart, Private, Co. C, 8th Michigan Vols., aged 30. Admitted to the Stanton U. S. Army General Hospital May 25, 1864; wounded in battle near Spottsylvania C. H., Va., by a minie ball, which entered his back near the right axilla, and passing towards the spine fractured the 8th rib and lodged. At the time of admittance there was high febrile action; pulse small and quick; a great deal of nervous excitement; complexion sallow; tongue coated; had

[1] Vide relation between Osteo-myelitis and Pyæmia in Chapter First, Section Second.

cough, accompanied by pain, over left side of chest; bowels constipated; discharge from the wound thin and sanguineous. The ball was extracted on the 30th, about an inch to the right of spinal column, by counter-incision. The first chill after admission occurred on the 26th, and pyæmic pneumonia was well marked on the 28th. The febrile symptoms abated after the 27th, but great nervous excitability lasted until June 1st, the day of his death. The treatment consisted of stimulants and sulph. quinia, given freely, combined with opiates.

Autopsy twenty-four hours after death. The lungs showed a number of superficial abscesses. The inferior lobe of the left lung was in the second stage of pneumonia, the greater portion of it being hepatized (red). There were also numerous patches of lobular pneumonia in the upper lobes. The left side of the thorax contained about 8 oz. of bloody serum. The right lung was much contracted, and bound to the posterior walls of the thorax by old pleuritic adhesions. Its apex contained numerous calcareous concretions, resulting from old or obsolete tubercles.

Liver enlarged, soft and yellow in color (fatty).

Kidneys very much enlarged, the two weighing 21½ oz. They were mottled in appearance, and the capsule peeled off readily. The cortical portion had twice the natural thickness. The pyramids were not well defined, and the whole presented a pale-yellow appearance.

The *spleen* was enlarged to about one third more than its normal size; was of a pale blue color and soft.

There was a large thrombus in the right ventricle of the heart, and another in right auricle; and small ones in left side of that organ.

Comments. — In this case, also, the disease progressed rapidly to a fatal termination, but the symptoms which were developed in connection with the pyæmic invasion, were not so violent as those which characterized the preceding case. The pyæmic intoxication appeared to have been produced more slowly in this instance than in the preceding one, and hence we are not surprised to find that the patient survived the attack for a longer period.

Case III. *Secondary Amputation at Knee-joint for Gunshot Injuries; Acute Pyæmia developed Three Days afterwards; Death on Eighth Day after Attack; Stump Muscles infiltrated with Pus; Osteo-myelitis (Carnification); Thrombosis of Superficial Femoral, Profunda, and External Iliac Veins; Spleen Pale and Softened; Liver Enlarged, Fatty, and Softened; Secondary Abscesses in Lungs.* — Peter Ostre, Private, Co. H, 72d New York Vols., aged 21. Admitted to the Stanton U. S. Army General Hospital, May 13, 1864; wounded in the battle of the Wilderness, Va., May 10, 1864, by a minie ball, which entered on the posterior aspect of right leg, just above the ankle-joint, and passing forward through the limb, fractured the lower end of the tibia, implicating the joint with comminution. Constitutional condition of the patient, weak;

injured parts, together with the foot and leg, very much swollen; diffuse inflammation extending up the leg to near the knee; ankle-joint open and suppurating. The limb was amputated at the knee-joint May 21st, by a long anterior and short posterior flap. There was not sufficient healthy tissue to permit amputation of the leg. The cellular tissue presented a gelatinous appearance at the place of operation. He suffered a good deal of shock, and reacted but slowly. Anæsthetic, sulphuric ether. For the first two days after the operation a slight improvement took place. There was a profuse discharge from the stump, but otherwise it looked well. The treatment during this time consisted of stimulants and sulph. quinia, in full doses, with opiates at night, and water-dressings to the stump. On the 24th he had a severe chill. Afterwards the tongue became coated, and the complexion assumed a bronzed hue. Profuse nocturnal sweats having a sweet sickish odor accompanied these symptoms, all of which increased in severity. The discharge became more thin and fetid, and the chills increased in frequency. The same treatment was continued, with the addition of a wash of the permanganate of potassa. Operator Assistant Surgeon G. A. Mursick, U. S. Vols.

The patient died June 1st.

Autopsy twelve hours after death. Muscles of the thigh infiltrated with pus. Thrombus of the superficial femoral, profunda, and external iliac veins.

Lungs contained numerous superficial abscesses (about one dozen); there were also patches of lobular pneumonia scattered through both lungs.

Liver enlarged, pale-yellow in color (fatty), and softened.

Spleen not enlarged, but paler in color than natural, and softened.

Kidneys presented no abnormal appearance.

Heart, right ventricle and auricle contained a large thrombus; left, small ones.

The cancellous structure of the lower end of the femur (epiphysis) in the stump, presented a hyperæmic appearance, being redder than natural, because the medullary tissue which fills the cancelli in this situation was inflamed, and in a state of red hepatization, or carnification, on that account. The inflamed medullary tissue was not submitted to microscopical examination, and, therefore, it is impossible for us now to say with certainty whether the process of suppuration had yet commenced in it. Examination of the bone.

Case IV. *Acute Pyæmia, following Secondary Resection of Tarsus, for Gunshot Injury, on Second Day after Operation; Death on the Eighth Day after that; Autopsy; Gangrenous Osteo-myelitis; Thrombosis Venæ Femoralis; Secondary Abscesses in Lungs; Copious Pleuritic Effusion, of a Dark Color; Liver and Spleen Enlarged and Softened.*—

Joseph Davis, Private, Co. L, 1st Michigan Cavalry, aged 22. Admitted to Stanton U. S. Army General Hospital, June 4, 1864, from the field. Was wounded in action, near Salem Church, Va., May 28, by a minie ball, inflicting a severe wound of the left tarsus. The ball struck the foot a little below the external malleolus, and passed through the tarsus horizontally inwards and somewhat backwards, escaping a little below and behind the internal malleolus. It occasioned compound comminuted fracture of the calcaneum, astragalus, and posterior edge of the internal malleolus. June 10th, the ankle and foot were much swelled, inflamed, and very painful, the swelling extending up the leg. The edges of the orifice of both entrance and exit were pouting, and did not exhibit any tendency to close up. The discharge was thin and scanty. The wound had been treated with ice-dressings ever since he came to the hospital, but was manifestly growing worse. He now had a good deal of constitutional disturbance; pulse ranging from 110 to 120, and quick; skin dry and too warm; countenance pinched, and anxious; he was restless and got but little sleep; his tongue was coated and his appetite poor; his general condition was getting worse daily. Wishing to avoid secondary amputation of the leg, if possible, owing to the great fatality which attended said operation at that time in Stanton Hospital, the following operation was performed on the same day, June 10th. He was brought under the anæsthetic influence of sulphuric ether, and an incision made on the external side of the foot, from the orifice of entrance, first, to the base of the metatarsal bone of the little toe; second, to the base of the external malleolus; third, to the point of the heel; and, fourth, towards the dorsum of the foot, $2\frac{1}{2}$ inches. Resected the anterior extremity, and part of the external side of the calcaneum; also extracted some fragments of the astragalus, and a splinter from the posterior edge of the external malleolus. There was no shock. The limb was placed upon a wire splint (Smith's), bent to a right angle, then well padded, and applied to the posterior part of the leg and sole of the foot, where it was properly secured by roller bandages, for the purpose of keeping the ankle-joint in a fixed position. The wound was plugged with lint, the ice-dressing continued, and a full opiate given. The constitutional treatment consisted in the administration of nutrients, tonics, and stimulants. The operation was performed by the author.

June 11. — He was cheerful and free from pain. The local swelling and the irritative fever had abated.

June 12. — He had a severe pyæmic chill and sweat; quinia sulph. in full doses was added to the treatment.

June 13. — He was much worse; wound discharging a thin, dark-colored pus; chills and sweats increased in frequency and severity; complexion assumed a bronzed hue; breath bovine; body exhales a sweet mawkish smell; anorexia; debility; diarrhœa set in. Pneumonic symptoms also appeared, and a large proportion of blood was mingled with the sputa. He sank rapidly and died on the 20th.

Autopsy twenty hours after death. The ankle-joint contained pus, and the articulating surface of its bones was partially denuded of cartilage. The calcaneum was fractured entirely through, and its cancellous structure was gangrenous. The astragalo-scaphoid articulation contained pus, and the articulating surface of its bones was entirely denuded of cartilage. The connective tissue on the front of the leg was infiltrated with pus from the ankle-joint upwards, to the extent of three inches, and the tibia and fibula were denuded of periosteum to the extent of two inches.

The left pleural cavity contained a large quantity of dark-colored effusion, whereby the lung itself was compressed against the vertebral column. The inferior lobe of this lung contained an abscess about the size of an egg, which was filled with dark-colored and fetid pus. The right lung contained several small superficial abscesses, which were sursounded with patches of lobular pneumonia.

The liver and the spleen were both enlarged and softened, but the kidneys presented a normal appearance.

The femoral vein *was thrombosed*, and there were clots in both ventricles of the heart.

Comments. — In this case, also, osteo-myelitis supervened, which was conclusively shown by the gangrenous condition of the cancellous tissue belonging to the calcaneum, or, rather, the gangrenous condition of the medullary tissue which filled the cancelli of that bone. Besides, it is probable, that if the interior of the tibia and fibula had been examined, the marrow would have been found inflamed at and above the place where those bones were seen to be denuded of periosteum, at the post-mortem examination. Osteo-myelitis. It is also probable that the medullary tissue of the denuded portion of the tibia contained collections of purulent matter which were produced by the suppurative character of the inflammatory process involving that tissue. Furthermore, it is probable that the inflammatory process had extended to the medullary tissue of the tibia, prior to the performance of the resection of the tarsus, and if its presence there had then been recognized, it would have contra-indicated that operation, and called for amputation far up the limb.

The thrombosis of the femoral vein was a recent occurrence. The coagulated blood which filled that vein presented a fresh appearance, and had not yet undergone the puriform transformation, nor even become at all softened. Thrombus. It was, therefore, obvious that the thrombosis had not occasioned the visceral abscesses nor the inflammation of the lungs, since the morbid process in those organs was considerably older than the thrombus of the

femoral vein. The thrombosis was a more recent event than the pyæmia. This circumstance is important, because it shows that the pyæmic process, in this case, could not have had its origin in the thrombosis, and that if any relationship or necessary connection existed between them, the pyæmic process induced the formation of the thrombi.

The symptoms of irritative fever (or, speaking properly, the surgical fever of an irritative type), which were so strikingly relieved by the operation, had been produced entirely by local causes, namely, the inflammation of the various structures bordering upon and connected with the gunshot wound, such as the connective, the fibrous, the osseous, and the medullary tissues. The symptoms of the purulent infection did not make their appearance till two days after the operation. They presented a marked contrast to those of the surgical fever which preceded the operation. They denoted the occurrence of a poisoned condition of the blood and the whole system, under which the patient sank rapidly, and died on the eighth day after its advent.

The surgical fever and the pyæmic symptoms distinct.

The next two cases furnish us with instances of *chronic* pyæmia, in both of which the disease supervened during the after-treatment of gunshot injuries involving the osseous tissue. The first of them occurred in the author's practice.

Two cases of chronic pyæmia.

Case V. *Chronic Pyæmia following Gunshot Fracture of Thigh at Trochanter Major; it commenced on the Fourteenth Day after Injury; Death on the Forty-second Day of the Disease; Autopsy; Pyarthrosis of Hip; Neighboring Parts Infiltrated with Thin, Dark, Fetid Pus; Left Lung Inflamed; No Secondary Abscesses.* — Sergeant William Norton, Co. I, 5th Wisconsin Vols., aged 30, and of remarkably vigorous constitution, was wounded by fire-arms in battle at Fredericksburg, Va., May 3, 1863. The bullet (a conical one) penetrated the front of the right thigh (high up), and passing backwards fractured the femur at the trochanter major, and escaped behind. There was nothing remarkable in the position of the foot. He was admitted to the Stanton U. S. Army General Hospital

May 8. — The hip was swelled and painful; he was restless, and complained that he did not sleep at night; directed the limb to be put up in a straight splint; water-dressings to be applied to hip, and to take morphia sulph. gr. ½ at bed time: patient also to have a spare diet.

May 15. — Wound suppurating; a small piece of bone came from it; pulse 105 and irritable; prescribed quiniæ sulph. grs ii., pulv. doveri, grs. v., ter in die.

May 17. — Has fever; skin hot and dry, and of a yellowish hue; pulse 100, and quick; appetite poor.

May 20. — Sweats profusely; skin continues yellowish, and he has a decided pyæmic aspect; breath sweet; skin exhales a sickish smell; is dull and stupid; has not had any rigors; removed the straight splint and placed the limb in Hodgen's cradle apparatus; prescribed milk-punch, one pint daily, and he is to have eggs, milk, and beef-tea added to his diet.

May 23. — Condition continues about the same; wound suppurates freely and looks well; prescribed quiniæ sulph. grs. v. ter in die.

June 7. — Has diarrhœa; pulse 130 and feeble; prescribed pil opii et camph. aa. gr. i., every four hours.

June 12. — The diarrhœa has stopped; ordered porter, three pints daily, in place of milk punch, as he no longer likes the punch.

June 14. — Has slight diarrhœa again; prescribed tinct. ferri. muriat. gtts. xx., ter in die.

June 23. — Has improved somewhat in general condition; has still some diarrhœa; wound continues to suppurate freely; he now refuses porter; ordered spiritus vini gallici, and beef-tea, of each two oz. every two hours.

June 26. — Has cough and dyspnœa; has vomited three times during the past twenty-four hours; he is very much emaciated; he takes but little nourishment, and is obviously failing.

June 28. — He continued to sink, and died apparently of exhaustion. He had exhibited all the prominent symptoms of pyæmia, except rigors.

The *autopsy* showed the fracture to be through the neck and the trochanter major of the femur. The hip-joint and the parts about it were infiltrated with a thin, dark-colored, and fetid pus.

Nearly the whole of the left lung was inflamed (pneumonia in first stage); indeed all of it except the superior part of the upper lobe.

The liver and kidneys appeared to be fatty; spleen not enlarged nor softened.

No visceral abscesses were found.

Comments. — The symptoms of pyæmia presented by this patient, in whom the disease appeared in a *chronic* form, are essentially the same as those exhibited by the cases of acute pyæmia which we have already related, with the exception of a single prominent one, namely, rigors. This patient did not have any chills during the forty-two days that were consumed by the disease in running its course. But he did have febrile movement alternating with profuse sweats, a frequent, quick, and feeble pulse, a tawny hue of the skin, rapidly increasing debility, depression of spirits, mental hebetude, a sickish fermentative smell of breath and body, and finally a low form of delirium, a tongue at first coated and afterwards also dry and brown, loss of appetite, bilious vomiting, and colliquative diarrhœa, and at last cough, dyspnœa, and other symptoms of pneumonia appeared and closed the scene.

No chills.

It is worthy of remark that no visceral abscesses were found on making a *post-mortem* examination; but the hip-joint was the seat of a collection of thin, dark-colored, stinking pus. The medullary tissue of the broken femur was not examined, but, judging from what I have found in similar cases, I do not doubt that it was the seat of a suppurative inflammation.[1]

Pus in hip-joint.

Case VI. *Gunshot Wound of Walls of Thorax; Pleural Cavity opened; Pyæmia; Result not stated; but his Symptoms were becoming more favorable.* — Joseph Prater, 41st Ala. (Confederate), was wounded, February 24, 1865, by a ball, which, breaking the eighth rib, passed through the pleural cavity, but not wounding the lung. The intercostal artery bled freely at first, but soon ceased spontaneously. Has discharged large quantities of pus from cavity of pleura. About the last of March had chills and sweats, and was delirious. An abscess formed on left cheek-bone; discharge from it still continues. Chills have ceased; appetite improving; breath sweet; tongue flabby and moist; pulse feeble. Has taken tonics.

Abscess in face.

In this case a so-called metastatic abscess was formed in the face, apparently in relation with the left cheek-bone. The report was contributed by Dr. Charles A. Leale, late Acting Assistant Surgeon, U. S. Army.

Symptoms.

Symptoms of Pyæmia. — An attack of pyæmia is usually ushered in by the following symptoms: The patient has rigors, which are generally severe and occur at irregular intervals, but sometimes they take place with considerable regularity once, twice, or three times in twenty-four hours — occasionally, however, they are entirely wanting; the skin becomes hot and peculiarly pungent in feel, followed by sweating, in some instances, but in other instances the patient exhibits an alternation of hot flushings and sweats and rigors occurring at very irregular intervals; if he has an unhealed wound the purulent discharge from it usually becomes scanty and thin, and sometimes fetid; the granulations, in many instances, at first present a pale and flabby appearance, and afterwards a dirty or sloughy look, but occasionally the wound continues to granulate and look tolerably well until near the fatal close; the pulse becomes frequent, quick, or irritable, and feeble, the countenance speedily becomes pallid and anxious, the features grow pinched and sharpened, the complexion soon assumes a sallow, tawny, bronzed, icteroid, or even

Yellow skin.

[1] Vide Pyarthrosis in chapter on Osteo-myelitis.

bright-yellow color; the patient rapidly loses his strength; his breath, at an early period, acquires a sickish, sweet fermentative, or bovine odor; his perspiration and body, in general, soon afterwards exhale the same disagreeable smell; he loses his appetite, and in a little time gets nausea, looseness of the bowels, vomiting of bilious matter, and colliquative diarrhœa; his tongue is furred at the commencement of the attack, but subsequently becomes dry and brown, and sordes accumulates upon his teeth and lips; he exhibits much disturbance of the nervous system; at first he is anxious and his spirits are much depressed, then he exhibits intellectual torpor and dullness with mild delirium at night, from which, however, he can be roused by speaking to him; afterwards the delirium grows more profound, he has colliquative sweats, his flesh and strength rapidly waste away, his countenance becomes hippocratic, and at last he dies apparently from exhaustion. Odor of breath, etc.

The next three cases are introduced for the purpose of illustrating the symptoms of pyæmia.

Case VII. *Chronic Pyæmia following Gunshot Wound of Right Shoulder beneath Clavicle; Death; no Autopsy.* The report of this case was contributed by Dr. W. Clendenin, late Surgeon U. S. Vols. — Lieutenant ——— ———, admitted to hospital at Nashville, Oct. 8, from the battle-field of Chickamauga, with a gunshot wound immediately below the right clavicle, a little external to its middle. Two days before admission (Oct. 6), hemorrhage occurred, and was controlled by digital compression. When admitted to hospital the patient looked pale and exsanguined; temperature of the body slightly increased; pulse 144, and small; tongue coated, pale, and moist; no appetite; bowels costive; had no sleep for two nights; last night had a chill. On removing the dressings a large quantity of fluid of a dark-brown color run out suddenly; this fluid was thin, vesicular, and offensive to the smell. Under the impression that the bleeding was venous, a compress with the addition of powdered persulphate of iron was put upon the wound with a truss.

October 9. — Pulse 144; rested well, having taken morphia sulph. gr. ¼ at bed-time; bowels were acted upon by enemata; evening, pulse 168.

October 10. — Night restless; bowels loose; pulse 146; removed the dressings, the wound discharged a large quantity of dark-greenish and extremely putrid fluid; after being cleansed the wound was found to be about four inches deep; wound in the skin two inches in its long diameter, and its borders undermined. The wound was washed out with a weak solution of bromine. Wine whey and essence of beef were

allowed ad libitum. The muscles of the region appeared through the wound like an anatomical dissection; the subcutaneous and intermuscular tissues being perfectly destroyed; the pulsations of the subclavian artery were distinctly visible through the wound.

October 11. — Hemorrhage from the thoracic branch of the thoracica-acromialis; ligated the bleeding vessel in the wound; pulse 148; no appetite; bowels irritable; emphysema over the entire pectoralis major muscle. Ordered acid sulph. aromat. ʒi, fld. extract cinchonæ, ʒi, aqua font. ʒv. Dose, one tablespoonful every two hours.

October 12. — Pulse 138; yellowish tint of face; appetite improving.

October 13. — Wound still emits a fetid discharge; on the upper part of the wound some thick healthy pus is formed. The probe falls nearly six inches deep into the wound; the ball is lying in the subscapular fossa. Continued tonic mixture, with beef-tea and egg-nog.

October 14. — Pulse 120; wound covered with a grayish matter.

October 15. — Pulse 120; evening, 132.

October 16. — Chill last night, and this morning sweating; emphysema continues to extend over the thorax; pulse 132; made a counter opening just below the anterior border of the scapula, two inches above the inferior angle of the scapula, but was unable to extract the ball.

October 19. — Pulse 134; cough at night; chill last night; evening, respiration frequent; sordes forming on the teeth; pulse 140.

October 20. — Pulse 144; rested well; respiration easier; evening, pulse 136; perspiration profuse; body emitting a very disagreeable odor.

October 21. — Chill at night; face pale; sordes on the teeth; tongue moist and coated; perspiration profuse and odor disagreeable; appetite failing; evening, the patient is sinking, pulse 168; chill.

October 22. — Coughs more; pulse 170, feeble and fluttering; evening, death supervened at nine o'clock.

A post mortem examination could not be obtained, as the wife of deceased was present and took the body home for interment.

Case VIII. *Resection of Fibula in Continuity for Gunshot Fracture; Pyæmia appeared on Thirty-eighth Day after Operation; Four Days afterwards Profuse Parenchymatous Hemorrhage occurred; arrested it by Styptics and Pressure; Death Five Days later still; no Autopsy.* — Andrew McIntyre, Corporal, Company C, 6th New York Heavy Artillery, aged 37. Admitted July 1, 1864, to the Stanton U. S. Army General Hospital, was wounded in battle before Petersburg, Va., June 22, by a minie ball, which entered the outer side of his left leg, fractured the fibula and passed through the calf behind the tibia. The operation for resection was performed June 23, and about three inches of the upper third of the fibula were removed. The operation consisted in part of a straight incision on the outer side of the leg immediately over the bone.

At the time of his admission to the hospital his general condition was weak, appetite poor and bowels constipated; the discharge from the wound was copious and thin. Stimulants, iron, and a full diet were ordered; the limb was bandaged as high up as the wound, and placed in Hodgen's cradle-splint. Ice-dressings and a wash of permanganate of potassa were applied. There was a slight improvement in his condition up to August 1st, at which time his appetite began to fail and his stomach rejected stimulants. Bismuth. subnitras was administered, and sinapisms applied over the region of the stomach. The stimulants were changed to brandy, but very little benefit was derived from this treatment. His pulse became weaker, the surface of his body assumed a yellow hue and exhaled a sickish fermentative odor. On the afternoon of August 5th parenchymatous hemorrhage to the amount of sixteen ounces took place suddenly. My finger introduced into the wound readily discovered the posterior tibial artery beating in front of it. There was also the tibial pulse at the ankle. The blood was red in color, not dark nor very bright, and flowed in a large stream, but not per saltem. It was controlled by injecting liquor ferri persulph.; the bandage was continued up the leg so as to cover the wound. Great prostration from the loss of blood occurred. Stimulants were frequently administered, and acid sulph. aromat. gtts. x. every four hours ordered.

August 6. — Removed the bandage; a large quantity of fetid pus mingled with coagulated blood, discolored by the persulphate of iron, oozed out of both the wound of operation and the one made by the exit of the ball. Continued the same treatment and reapplied the bandage as high up only as the wound. On the morning of the 7th, he had a severe chill (pyæmic); ordered quinia sulph. grs. xv. in solution, which was immediately rejected by the stomach; during the night he had two more severe chills; morning of the 8th, complexion bronzed; breath bovine or fermentative in smell; surface covered with a cold perspiration; pulse very weak; takes his stimulants and acid sulph. aromat., but rejects all food; had a repetition of the chills.

August 9. — Has cough; spits thick mucus; there is a little dullness over the base of left lung, and crepitation throughout both lungs. Evening, pulse very weak; respiration quick, and labored; refuses medicine and stimulants. He died on the morning of the 10th. No autopsy could be obtained. This case occurred in the author's practice.

The report of the next case was contributed by Prof. Hamilton.

Case IX. *Acute Pyæmia following Lacerated Wound of Great Toe inflicted by a Circular Saw; Last Phalanx severed; Disease appeared on Nineteenth Day; Death on Seventh Day afterwards; Wound healthy and almost healed; no Autopsy allowed.* — Peter Henry, aged 14, a native of New York, and a woodcutter by trade, was brought into the Bellevue Hospital by a policeman, on January 30, 1866, with a lacerated wound

of the left great toe. The wound had been inflicted by a circular saw; it was transverse and completely severed the last phalanx, the end of the toe hanging by a strip of integument about half an inch in width.

The parts were placed in apposition and retained by adhesive plaster. The bone apparently united in a short time, and the wound assumed a healthy appearance. There were no bad symptoms until February 18, when he had a severe chill, which was followed by a high fever, and a profuse perspiration. The wound was carefully examined, but as it still had a healthy appearance, and as there were no signs of inflammation along the course of the veins or lymphatics, we were disposed to regard it as a case of intermittent fever and treated it accordingly.

For the next four days, although he had no distinct chills, he had slight rigors followed by high febrile action and moderate diaphoresis.

Dr. Hamilton saw him on the 22d, and, as at this time there was some tendency to diarrhœa, he was disposed to regard it as a case of typhoid fever. At this time the wound looked perfectly healthy, nor had he complained of any pain except in his head. On February 23d he was transferred to the pavilion. He had a full pulse of 120, easily compressible; his tongue was covered by a thick, brownish coat, and his skin covered by a profuse perspiration.

He now for the first time complained of a severe pain in the gluteal region of the left side; there was also a severe pain along the inner surface of the left thigh; there was no swelling nor redness at these points. The pain was constant, and was not at this time much increased by pressure.

February 24. — There is to-day great pain on pressure just behind the trochanter major, and along the inner surface of the thigh. Pulse 120 and weak. Wound still healthy in appearance, and almost healed.

February 25. — He died this morning at five o'clock, apparently from asthenia. No autopsy allowed.

It is believed that the history of the last three cases illustrates with sufficient fullness and at the same time with sufficient minuteness the *symptomatology* of pyæmia.

Distinct from gangrenous septæmia.

We may also remark that the last two cases serve to show pretty clearly that pyæmia is a disorder quite distinct from gangrenous septæmia, because in both of them the wound was doing well (and most certainly not sloughing nor gangrenous) when pyæmia supervened, and in the last related it continued "healthy in appearance," until the fatal close. Many other cases of similar import are related in this and the preceding section of these Memoirs.

Diagnosis. — It is generally not difficult to make a diagnosis in cases of pyæmia, at least after the symptoms of the disease have be-

come fully developed. The rigors irregular in character and accompanied by hot flushings and sweats, the pungent heat of the skin, the extreme and rapidly increasing debility, the icteroid hue, the sickish saccharine odor of the breath and perspiration, the extreme feebleness and frequency of the pulse, the great amount of disturbance of the nervous system, as denoted at first by extreme anxiety and depression of spirits, soon followed, however, by hebetude, sopor, and mild delirium, taken together constitute such a combination of symptoms as attends upon no other disorder with which we are acquainted. During the first period of pyæmia, that is, the time prior to the full development of the disease, however, much difficulty may be experienced in arriving at a correct conclusion with regard to the exact nature of the disorder with which we have to deal. It sometimes happens at the commencement that our patient takes a chill which, after lasting a short time, is followed by febrile symptoms, and these in turn are succeeded by diaphoresis more or less profuse, and that he exhibits, in fact, a series of phenomena which resemble the cold, hot, and sweating stages of intermittent fever so closely as to lead us to hope that he is afflicted with some malarial disorder and not with pyæmia. It sometimes happens in other instances that our patient presents at the commencement and for several days afterwards only the symptoms of surgical fever of a typhoid type. In both of these classes of pyæmic cases, however, the various symptoms of pyæmia above mentioned will make their appearance, sooner or later, in sufficient number and with such concurrence as to render the true character of the disease no longer doubtful.

Diagnosis not in general difficult.

Sometimes resembles, in certain symptoms, malarial disease.

In the typical cases of acute pyæmia where the chills are irregular in respect to their duration, and also in respect to the interval which elapses between them, where the sweats are profuse, the debility extreme, the icteroid hue and the bovine breath marked, the wandering delirium and the colliquative diarrhœa also present as symptoms, the diagnosis is never doubtful. It is only in the cases that are not typical that difficulty is ever experienced. But even in such instances we can always assist ourselves not a little by considering the symptoms taken together as a whole (in totality) in arriving at a just conclusion.

Prognosis. — It is almost unnecessary to say that the prospect of recovery for patients affected with pyæmia is very small. Mr. Simon, in his sixth report as medical officer of the privy council, of the British government, to which we have already referred, says,

"Of all the traumatic infections, of all the mischances to which major surgery is subject, pyæmia is by far the most fatal. Its attacks under ordinary circumstances are happily not frequent, but it kills nearly all whom it attacks."[1] Of fifty-nine cases of this disease which were treated in the Stanton U. S. Army General Hospital during the year ending September 30, 1864, as we have already stated, but three recovered. This affords a ratio of mortality of almost ninety-five per cent. It is my impression that this result is more favorable than that usually obtained in the treatment of traumatic pyæmia, owing I presume to accidental circumstances.

Ninety-five per cent died at Stanton U. S. Hospital.

The histories of the next three cases afford us examples wherein recovery from acute pyæmia took place. Two of them occurred in the author's practice. In another place we have also related an instance of this disease which had a favorable termination.[2]

Case X. *Resection of Right Shoulder-joint for Injury Inflicted by a Grape-shot; Pyæmia accompanied by Characteristic Symptoms; Recovery.* — Private R. S. Goodwin, Co. B, 11th Massachusetts Vols., aged 25, always healthy, was wounded at Chancellorsville, Va., May 5, 1863, by a grape-shot, which penetrated the antero-outer part of the right shoulder, and lodged therein; was sitting on the ground in line of battle when hit.

He was brought to the Stanton U. S. Army General Hospital, June 15, 1863, having previously been treated at Potomac Creek. There was a wound of operation about four inches long over the upper end of the humerus (outer side) which was suppurating freely. The acromion process of the scapula and the head of the humerus appeared to have been excised. His general condition was unfavorable, as he was thin, pale, and very weak. Subsequently he suffered from well marked purulent infection, having pyæmic rigors and sweats, occurring at irregular intervals, with a sweet breath and a dry brown tongue, weak and frequent pulse, with great debility, and he came near dying. He was also icteroid. He however ultimately recovered so as to leave the Hospital on furlough, October 16, 1863. Several small pieces of bone were discharged from the wound of operation during the treatment. The purulent infection was combated with quinine in full doses, opium, alcoholic stimulants, and nutrients.

February 13, 1864. — On examining this patient I find the shoulder anchylosed, and the arm standing out from the trunk at an acute angle; free motion of the elbow-joint, and he is slowly recovering the use of the hand and fore-arm.

May 10. — He was transferred to Philadelphia in good condition.

[1] Vide p. 61, London, 1864.

[2] Vide Case LIII., that of O'Connor, in the chapter on Ostitis.

Case XI. *Primary Amputation of Right Leg, for Injury Inflicted by a Cannon-ball; Pyæmia Developed Thirty-one Days afterwards, with Well Marked Symptoms; Recovery.* — Michael Brannan, Corporal, Co. B, 9th Massachusetts Vols., was wounded in battle at Cold Harbor, Va., June 3, 1864, by a solid cannon-shot, extensively comminuting both bones of the right leg, and lacerating the soft parts. Primary amputation was performed in the field hospital, at the upper third of the leg, by antero-posterior flaps. He says that he was in a good condition of health at the time of the operation. When admitted to this (Stanton) Hospital, June 12th, the stump had almost healed by primary adhesion. His general condition was good, appetite excellent, tongue clean, etc.; stimulants, tonics, and full diet were ordered, and he continued to improve until the latter part of June, when the end of the tibia protruded through the anterior flap, in consequence of ulceration.

July 4. — He had a well marked pyæmic chill and sweat. Quiniæ sulph. was administered in large doses.

July 5. — Patient restless all night; the discharge from the stump became thin, dark-colored, and fetid; a strong solution of permanganate of potassa was applied to the stump, and the ice-dressing continued.

July 6, 7, *and* 8. — The chills and sweats were repeated; tongue became coated; complexion assumed a yellow hue; his breath and sweat had a sweet, sickish, fermentative smell; he was much debilitated, and the stump commenced to slough. Dilute nitric acid was applied locally, and iron with stimulants and nutrients were given freely.

July 9. — Had no chill; the sloughing ceased; a slight diarrhœa set in, but it was checked with a few doses of bismuthi subnitras and opium.

July 11. — Stump becoming clean; patient's appetite improving; he sleeps well nights, and his general condition is much better; continue treatment.

July 16. — Stump granulating nicely.

July 27. — Stump nearly healed. A small sequestrum of the tibia came away, and then the stump closed kindly.

August 1. — His health is excellent, and he will be transferred in a few days to Judiciary Square Hospital, in order to be supplied with an artificial limb.

The report of the next case was contributed by Dr. Charles A. Leale, late Acting Assistant Surgeon U. S. Army.

Case XII. *Amputation of Thigh in Middle Third, for Shell-wound; Pyæmia supervened Twenty-eight Days afterwards; Recovery.* — Wm. H. Humphrey, 1st Lieut. Co. G, 4th Vermont, aged 29. Wounded at Petersburg, April 2, 1865, by shell. Shell entered and passed across popliteal space, fracturing the head of the tibia and fibula.

Appearance of stump when admitted very unhealthy, and does not

suppurate. Patient suffering great pain. Applied liquor sodæ chlor. to stump; gave anodynes and stimulants; appetite poor.

May 1. — Marked symptoms of pyæmia; gave iron and podophyllin mixture for three days, when the symptoms abated, and after that he continued to improve.

September 1. — Stump perfectly healed and solid.

Nature and Relations of Pyæmia. — This disease is never an idiopathic or primary affection. Its occurrence is always preceded by some local suppurative inflammation — by the formation of purulent matter or its equivalent in some part of the body. Even when connected with hospital gangrene it but very rarely if ever makes its appearance until that morbid process has been arrested and suppuration has been established in the wound. Thus on scrutinizing Dr. Goldsmith's condensed tabular statement of cases of hospital gangrene, I find that in one hundred and eighty-four cases of said disease pyæmia occurred but six times, that in five of them it supervened after the sores were granulating, or in other words suppurating, and that in but one instance did it appear before the gangrene was arrested.[1]

Not an idiopathic affection.

Again, pyæmia occurs in surgical practice but very seldom except in connection with wounds or other forms of surgical injury, and it does not appear even in them until suppuration is established. It may also with strict propriety be said that this disease belongs to the period of suppuration. The period when secondary hemorrhage occurs among the wounded is the period when pyæmia also is rife, namely, between the fourth and twenty-third days after injury. We have already shown in this essay that of fifty-one cases of pyæmia only eight supervened after the twenty-third day. As secondary hemorrhage sometimes occurs subsequent to the last named day, even so does pyæmia, but both of them are, nevertheless, diseases which belong to the period of suppuration, and derive their very existence from it.

Belongs to period of suppuration.

Between the 4th and 23d days.

But traumatic pyæmia is met with much more frequently when some tissues of the body are wounded than when others are the seat of injury. Every surgeon much experienced in the after-treatment of the wounded during the late War of the Rebellion must have noticed how seldom traumatic pyæmia supervened unless the bone was injured. Indeed, I have even heard it stated by surgeons of large experience in our military hospitals that they had never seen a case of traumatic

Not generally unless the bone is injured.

[1] Vide *Report on Hospital Gangrene*, etc., by M. Goldsmith, Surgeon U. S. Vols., Louisville, 1863.

pyæmia which was unconnected with a lesion of the osseous tissue. This fact alone shows that in a very large majority of instances this disease follows and is connected with injury of bone. On this point Mr. Simon says: —

"Not all surgical patients having wounds have an equal, or nearly equal, liability to it. It shows an almost infinite preference for the cases where bone-structure (particularly cancellous bone-structure) has been injured, as in compound fracture, or in the surgical procedures of amputation and resection, and all the more, perhaps, in proportion as the injured bone is large." [1]

Especially cancellous structure.

We have elsewhere shown that a remarkably close relationship exists between *osteo-myelitis*, or rather the suppurative form of that disease, and pyæmia.[2] When inflammation of the medullary tissue of bone proves fatal it does so in a large majority of instances by the induction of purulent infection. Numerous examples of pyæmia following suppurative osteo-myelitis of a traumatic origin are related in the chapter mentioned in the note. Pyæmia is the form of systematic poisoning which osteo-myelitis generally produces. The following case affords another illustration of the correctness of this statement. The report of it was contributed by Dr. Charles A. Leale, late Acting Assistant Surgeon U. S. Army.

Relations to osteo-myelitis.

Case XIII. *Secondary Amputation of Arm for Gunshot Injury; Acute Pyæmia suddenly supervened after Stump was healed; Death; Autopsy; Suppurative Osteo-myelitis of Stump-bone; Abscess of Liver; other Viscera sound.* — William Collins, Captain Co. G, 5th N. H. Vols., aged 35. Wounded at Farmville, April 7, 1865, by a conical ball, which passed through right arm an inch above the elbow-joint, fracturing humerus. The limb was amputated in middle third by flap method, at the Second Army Corps Depot Field Hospital, City Point, Va. Operator's name not known.

When admitted to Armory Square Hospital, April 16, 1865, the stump had entirely healed, and there were no sinuses leading to the bone.

The general condition of the patient was very good; appetite good; walked about the ward since he was admitted.

April 23. — Pyæmic symptoms noticed; has had several chills during the day; continued nausea with an occasional spell of vomiting; at night was bathed in perspiration; gave quiniæ sulph. iron, stimulants, and beef-tea; during the day had him removed out of the ward and placed under the shade trees in the garden.

[1] *Sixth Report of Medical officer to Privy Council*, p. 61.

[2] Vide chapter on Osteo-myelitis in Section Second.

April 28. — A small opening formed in end of stump, through which hemorrhage has taken place. This oozing of blood was checked by the application of styptics. Diarrhœa commenced, which resisted the usual treatment, and injections (astringent). He has become very anæmic; continued treatment.

April 29. — He died.

The *autopsy* showed, after the end of the humerus had been sawn off and broken open, that its medullary canal contained a large quantity of pus, which had obviously been produced by osteo-myelitis of the stump-bone.

The liver contained a large abscess, filled with thick pus. The spleen, kidneys, and lungs were natural. No pus was found in the joints.

Comments. — It is worthy of special remark that in the foregoing case "the stump had entirely healed," and that the focus of suppuration or the collection of purulent matter from which the pyæmia sprung, was confined to the medullary canal of the stump-bone. Now clinical observation has shown that inflammation of the medullary tissue is a not infrequent consequence of injury of bone. Clinical observation has further shown that when said disease proves fatal it generally achieves that result by the induction of pyæmia. Is it not therefore probable that the intimate relationship which subsists between pyæmia and injury of the osseous tissue, which we have already pointed out, depends upon the intervention of suppurative osteo-myelitis? The medullary tissue of the injured bone becomes inflamed, purulent matter is formed in it, and then pyæmia follows. These considerations are possessed of great practical importance. They seem to show us that the way of defending the wounded and the injured, having bone-lesions, against death by pyæmia, consists in preventing the medullary tissue of the injured bone from becoming the seat of suppurative inflammation.

Did not originate directly from wound of soft parts.

Again, the development of pyæmia is not unfrequently preceded or accompanied by distinctly marked inflammation of the lymphatic vessels which proceed from the wounded part. In some cases, like the following, for example, it would seem that the inflammation of the absorbent vessels performs no inconsiderable part in the production of pyæmia. It is also worthy of mention in this place that in a large majority of the cases of traumatic pyæmia, more or less inflammation of the absorbent vessels which proceed from the injured part is exhibited. In some, the presence of such inflammation is denoted by well marked symptoms during

Absorbent vessels.

life, as it was in the following case. In others its existence during life is announced only by the enlargement and tenderness of the lymphatic glands belonging to the affected part. And in still others its presence is not ascertained until after death, when on making the autopsy the lymphatic glands in relation with the diseased part are found to be enlarged, reddened, infiltrated with serum, and in some instances suppurating at the centre. Several additional examples of inflammation of the lymphatic vessels occurring in relation with pyæmia, will be presented when we come to speak of the morbid anatomy of this disease.

The following case occurred in the practice of the late Professor Enos, of Brooklyn: —

Case XIV. *Acute Pyæmia, following Gunshot Wound, involving First Phalanx of Great Toe on the Fifth Day; Death on the Twelfth Day afterwards; no Autopsy.* — D. S. McIntire, aged 22, clerk, born in Ireland, admitted to the Brooklyn City Hospital, December 7, 1865, for a gunshot wound of the left great toe. His general appearance was healthful, though his habits had been irregular. December 9, Dr. Enos enlarged the wound (the patient being etherized), and removed in fragments a ball which had been accidentally discharged from a pistol, while in the pocket of his overcoat. Several pieces of bone were removed from the first phalanx, which, though shattered, was not entirely broken through, neither were the articulations involved. The operation was followed by much inflammation and suppuration. The third day the discharge appeared healthy and moderate in amount, but the foot was very painful and œdematous. Patient was feverish and said he felt sick all over. Morph. sulph. gr. ¼ was put in the wound, and a poultice applied. He took liquor ammoniæ acetatis and spts. ether. nitric. with nourishing broth and milk-punch. The morphine did not relieve the pain; the leg became swelled and tender, and red lines were seen running up the inner side of the thigh, along the track of the absorbent vessels; the glands in the groin also became swollen. The leg was painted with equal parts of tinct. iodini and tinct. opii. The pulse run up to 140; thirst great; tongue brown and coated. Stimulants were increased, and sulphite sodæ gr. xv. were given thrice daily, in solution; he vomits his food, but his appetite is fair. The wound looks well, but his face is much shrunken. He gradually sank, and died on the fifteenth day after the operation.

His friends removed him from the hospital the day before he died, doubtless to avoid what we desired, namely, a post-mortem examination, so none was obtained.

But, while it is true that traumatic pyæmia is generally connected with some lesion of the osseous tissue, it also occasionally

happens that this disease is developed in cases where the injury has been confined to the soft parts and the osseous structure is intact. In some cases of traumatic pyæmia wherein the soft structures alone appear to be wounded, it may happen that the osseous tissue has sustained some hidden injury, and that this tissue is in reality the source of the pyæmic mischief. We see this take place not unfrequently in the cases of "contusion of bone." [1] It is therefore necessary to ascertain the condition of the bone, by submitting it to actual examination in many instances, where the injury appears to be confined to the soft parts, before we can say with certainty that such is in reality the case.

Traumatic pyæmia without injury of bone.

Concerning traumatic pyæmia unconnected with bone-injury, it may be remarked that wounds of the soft structures which involve the blood-vessels [2] are more liable to be followed by this accident than wounds which involve the muscular and cellular structures alone. Nevertheless, we occasionally see a case wherein the local injury is confined to the skin, together with the subjacent muscular and connective tissue, as happened in the following instance, which occurred in the author's practice.

CASE XV. *Flesh Wound of Thigh at Upper Third and Outer Side, inflicted by a Shell; Sloughing; Pyæmia; Death on Forty-first Day after Injury, and Thirteenth after the First Chill.* — Private John Grieder, Co. D, 2d Reg't Connecticut Heavy Artillery, aged 25. Was wounded near Petersburg, Va., June 20, 1864, by the explosion of a shell, which lacerated the flesh at the outer side of the left thigh, in its upper third. He was admitted to the Stanton U. S. Army General Hospital, July 4. The wound was then much inflamed, but the patient's condition in other respects was good. Ordered the ice-dressing for wound, and spts. frumenti f. ʒi. ter in die., with a full diet.

July 8. — Wound discharges freely, but the pus is inclined to burrow in the connective tissue, between the muscles. Directed a bandage to be applied to limb, from the toes up to the wound.

July 18. — He had a chill. Prescribed quiniæ sulph. grs. x., ter in die, and increased the allowance of whiskey to 8 oz. per day.

July 21. — Leg and knee swollen, and there is considerable heat about the joint; ordered the ice-dressing to be applied to knee.

[1] Vide Chapter on Osteo-myelitis.

[2] Of the cases of secondary hemmorhage related in Section First, seven or eight died of *pyæmia*. It is, however, known that in all but two or three of this fatal group the wound of blood-vessel was associated with some corresponding injury of bone, and therefore it is impossible to say, with regard to at least five of them, which had most to do in producing pyæmia — the vascular, or the osseous lesion. But the circumstance still remains conspicuous that pyæmia is often connected with injury of blood-vessels.

July 26. — He had another chill during previous night; knee continues much swelled and hot; the wound is sloughing; patient weak.

July 28. — Sloughing has extended rapidly, and involves nearly the whole length of the thigh, together with the glutei muscles, to considerable extent. Patient's strength is failing rapidly. He has fallen into a typhoid condition, with dry, brown tongue, anorexia, diarrhœa, delirium, chills and sweats occurring at irregular intervals, a tawny hue of the skin, saccharine or fermentative smelling breath and perspiration, and great debility. Applied acid nitric. dilut. to sloughing surface, and directed it to be dressed with a yeast poultice.

July 31. — He died of pyæmia.

Non-traumatic pyæmia.

Again, although purulent infection occurs but seldom except in connection with wounds and other forms of surgical injury, we sometimes meet with it entirely separate from that relation, and the disease is then called non-traumatic pyæmia. It has been produced by intestinal ulceration occurring in the course of typhoid fever, by furuncle, by anthrax, by carbuncle, by abscess, by empyema, and by diffuse phlegmon.

Consequent upon camp fever.

The following case presents us with an example of it occurring in connection with camp fever in military practice. The pyæmic intoxication appears to have had its origin in a collection of purulent matter which was formed in the left pleural cavity.

Case XVI. *Pyæmia, following Typho-malarial Fever; Empyema, together with Visceral Abscesses in the Liver and Spleen, found at the Autopsy;* for the notes of it the author is indebted to Dr. George A. Mursick, late Assistant Surgeon U. S. Vols. — Private Miles Ivers, Co. F, 6th Wisconsin Vols., was admitted to the Stanton U. S. Army Gen. Hospital, April 21, 1864, from the field, being sick with camp fever. He stated that he had been sick about a week with a fever, which commenced with chills. When admitted to hospital he was much prostrated; bowels loose; tongue dry, coated, brown in centre, and red at edges; skin hot and dry; pulse frequent and feeble. Treatment: prescribed quinia, alcoholic stimulants, and nutrients adapted to his condition. A few days after admission he complained of pain in the left side. His respiration was also accelerated, and he had some cough. A number of blisters (emplast. cantharidis), in succession, was applied to his side, and the other medication was continued. Under this treatment the patient gradually improved, and the fever subsided. A considerable quantity of fluid, however, remained in the left pleural cavity. To promote its absorption, the iodide of potassium was administered in full doses, and a blister was occasionally applied to his chest. But the effu-

sion did not diminish rapidly in quantity; his convalescence was exceedingly slow, and he continued unable to leave his bed.

About the first of June he began to exhibit symptoms of the pyæmic intoxication. He had fever at irregular intervals, sweet breath, and profuse sweats; his appetite was very poor, and he would take but little nourishment besides milk-punch. The quantity of fluid in his chest at this time, however, was not large, and his respiration was not embarrassed to any considerable extent. But he gradually failed in strength, and died June 21st. He did not complain of chills at any time after his admission to the hospital.

Autopsy twenty-four hours after death. Body much emaciated; rigor mortis moderate. Upon opening the *thorax*, the left pleural cavity was found to contain about a pint and a half of purulent fluid, and the lung was compressed back against the spinal column. The right pleural cavity contained about six ounces of serum. The pulmonary tissue of both lungs was healthy.

Abdomen. — The intestines were filled with gas. The mucous membrane of the stomach and entire intestinal canal was thickened and softened. The glands of Brunner and the solitary glands of the ilium were enlarged and prominent, but not ulcerated. The patches of Peyer presented the "newly-shaved chin" appearance. The liver was about one-third larger than natural (weight not noted), and contained a very large number of minute abscesses. The spleen was about three times its normal size, and contained a large number of abscesses, varying in size from the head of a pin to that of a hazel-nut. The kidneys appeared healthy.

Comments. — In this case the general purulent infection in all probability resulted directly from the suppurative inflammation of the pleura. If that complication had not supervened, it is not likely that pyæmia would have occurred as a consequence of the fever alone. It is probable that the camp fever exerted considerable influence in producing the suppurative inflammation of the pleura, which in turn occasioned the pyæmia.

Connected with pyothorax.

The very considerable enlargement to which the spleen had been subjected, constitutes another interesting feature of this case.

Causes of Pyæmia. — With regard to the *predisposing causes* of pyæmia, it was generally observed during the late War of the Rebellion, that while the strong and robust were not exempt from its ravages, the feeble and the unhealthy were considerably more liable to be attacked by it. Thus, it generally happens that when troops are first brought into the field they suffer but little from pyæmia, but as soon as they become enfeebled by ardu-

Predisposing causes.

ous duty, by scanty and unwholesome diet, by the constitutional effects of malaria, and by exposure to the elements, many of the wounded fall victims to this disease. Among the wounded who came under the author's observation during the first year of the late War of the Rebellion, (*i. e.* prior to May, 1862), and the number was considerable, but very few cases of pyæmia occurred; but subsequently this disease became quite common. Mounier states that during the Crimean war, no pyæmia was noted among the first 2,000 amputations, whilst afterwards it became of quite ordinary occurrence, associated with gangrene, scurvy, and typhoid fever.[1] There is no doubt but that those among the wounded who are debilitated by malarial disease and by scurvy, are considerably more liable to be struck down by pyæmia than those who are strong and heathy.

This disease is not limited to any particular period of life, although it occurs least frequently in the young. However, one of the cases whose history is related in these pages, was but fourteen years of age, and it has also been known to prove fatal to very young children. Influence of age.

With regard to the *efficient cause* of pyæmia, while we can confidently assert on the one hand that it has not yet been shown to consist in the presence of pus in the blood, nor to be necessarily connected with thrombosis,[2] nor with gangrene,[3] we are compelled to confess on the other hand that it is shrouded in doubt and obscurity. On this point Mr. Simon makes the following judicious observations: — Efficient cause.

"The local changes which in either sort of case precede and introduce the pyæmia are not hitherto well understood. But we know that very often they are part and parcel of a process which is not simply suppurative, but involves also much foulness of wound; and we know that among them the putrefactive softening of local blood-clot and other fibrinous matter has generally an important, if it have not always an essential place. For commonly, till they set in, there will have existed protectively in each injured vein of the part firm blood-clot of greater or less extent, closing the vein towards the focus of traumatic irritation; but now these barrier-clots undergoing just such a change as clot undergoes when it putrefies after removal from the body, soften and fuse away, partly at least into the circulation, — where apparently it is the ferment-action of their material, or of material which their fusion lets enter from adjoining sources, that establishes the pyæmic state, and therewith usually more or less of common Putrefaction of blood-clot.

[1] See *Holmes' Surgery*, vol. i. p. 269.
[2] Vide *infra*.
[3] See Section Second, pp. 406–407.

putrid infection of the blood. That pyæmia so often presupposes a local working of putrefactive ferments, is a fact which concurs, I think, with other evidence to suggest the pathological affinities of the disease. Probably the putrefactive softening of blood-clot plays an equally important part in relation to the occurrence of secondary hemorrhage from tied arteries, — a part far more important than the mere anatomical conditions to which, in the olden literature of this subject, a too exclusive consideration has been given. Finally, that also phagedenic and gangrenous processes are in their very essence processes of death and putrefaction for the parts which they affect, is a fact which is on the very surface of their pathology; and that at least some of these processes are true zymotic diseases,[1] is rendered probable by very strong considerations of analogy, as well as by statements which have been published of their inoculability from patient to patient."

"An attack of any of these traumatic infections has generally the same meaning as an attack of traumatic erysipelas. It is true that any member of the whole series — erysipelas, pyæmia, softening of clot, gangrene, phagedena — may, within a large surgical experience, occur to some considerable extent from causes which are purely personal. And (especially where such is the origin) one of them may occur without the others. But, except where personal conditions exclusively decide the occurrence of these lamentable infections (and clearly this is only to a limited extent), they tend to prevail conjointly or in succession. That they differ somewhat from one another in the intimate nature of their respective chemical processes is possible or even probable; — but that they have in common an intimate affinity with ordinary putrefactive processes seems to be the leading fact in their pathology. Provisionally I regard them all as zymotic diseases, the respective contagion of which may arise in any putrefaction of wound-products."[2]

Pathological Anatomy of Pyæmia. — We will next proceed to consider the various anatomical lesions which are produced by pyæmia.

CASE XVII. *Acute Pyæmia following Secondary Amputation of Arm for Gunshot Injury of Fore-arm Nine Days after Operation; Death Four*

[1] Virchow, the author of the views concerning thrombosis now in vogue, has very ably shown the analogy which obtains between the phenomena produced by the pyæmic poison and those which are generally admitted to be zymotic in their nature. Like them it exhibits a remarkable affinity for certain organs and certain tissues, and in them produces the secondary lesions which are so constantly found in post-mortem examinations of pyæmic subjects. The pyæmic poison having become diffused through the system by the circulating blood, "*displays its effects in an acute form in the organs which have a special predilection for such matters.*" (See Virchow, *Lectures on Cellular Pathology*, p. 250, Amer. ed.) In my opinion, pyæmia is essentially a zymotic disease, and the pyæmic poison is primarily developed in the local suppuration.

[2] Vide *Sixth Report of Medical Officer of Privy Council*, pp. 61, 62. London, 1864.

Days after that; Autopsy; Stump resembles Dry Pork; Lower Lobe of Right Lung partly hepatized; Liver and Spleen enlarged; Ecchymoses in Alimentary Canal. — Captain George Reis, Co. C, 15th Regiment Missouri Vols., aged 31 years, a native of Germany, of bilious irritable constitution, but enjoying good health for the last two years. Said to have been a hard drinker before. Was shot while charging up Missionary Ridge, 25th November last.

November 25. — The ball pierced his right forearm, fracturing radius and ulna two inches below elbow-joint, went obliquely down, penetrated right thigh on outer side three inches above patella, and became lodged in calf of leg. Was seen eight hours after he received the wound. Arm and leg very much swollen; great depression from shock and hemorrhage; pulse 120, scarcely perceptible. Hand warm and sensitive to touch. The arm was placed on a pillow in semiflexed position. Arm and leg to be kept cool with water-dressings. To have some milk-punch every two hours till reaction.

November 26. — Had little sleep. Swelling the same, no hemorrhage; pulse 116, small, no traces of ball. Continue refrigerant dressing and punch. Evening, pulse 120, becoming fuller and hard; much pain and restlessness; to have $\frac{1}{2}$ grain of morphia.

November 27. — The same, pulse 112, softer. Patient not consenting to amputation, the arm was put up in splints, wounds remaining free and dressed with linseed-meal poultice. To have three cathartic pills, beef-tea, and punch.

November 28. — Pain diminished, swelling softer, pulse 110, had three evacuations. Continue treatment.

November 29. — Suppuration commences, swelling of arm decreasing, pulse 104, tongue moist and clean. Cont. treatment.

November 30. — Free discharge of good pus from entrance and exit hole. Leg and foot swelled, no pain in knee, pulse and tongue the same. A roller was applied to foot and leg; cataplasm to wound of thigh.

Patient continued to slowly improve for several days. His appetite returned, the pain was moderate, and with an occasional dose of morphia to insure rest at night, he was content. The pulse, however, kept always above 100. The swelling was limited to the neighborhood of the wound, which discharged about four ounces of good-looking pus daily; leg painful.

December 4. — Deep fluctuation was detected in leg, and an incision on the outer border of m. gastrocnemius gave exit to eight ounces of thick, healthy pus. No ball could be detected, as the patient's great irritability prevented a thorough examination.

December 5. — Pain and swelling of leg have disappeared; much pain in arm; discharge dark and offensive; inflammation limited to the parts below elbow; tongue moist and slightly furred; pulse 102 and soft.

December 6. — Patient finally consenting to amputation of arm, the bilateral flap operation was performed below the deltoid muscle. Three ligatures were required; dressed stump with lint soaked in tepid water. Evening, stump painful; no rest. ℞ morph. sulph. gr. ½.

December 7. — Feels better; pulse 98; tongue moist and slightly coated; to have generous diet and wine.

December 8. — Pulse 96; stump painful; leg doing well; in the evening hemorrhage occurred from the stump to the amount of five or six ounces before the bleeding vessel, a small muscular branch, could be secured; pulse 124; to have beef-tea and wine.

December 9. — Flaps covered with a greenish-gray coat, swelled and painful; pulse 116; tongue coated; warm-water dressing to stump.

December 10. — Flaps sloughy; tongue coated; pulse 110; bowels not open for two days; to have enema of warm soap-water and ol. ricini ʒss.

December 11. — Suppuration commences; slough separating; bowels open; tongue cleaner; pulse 104.

December 12. — Improving in every respect; pulse 100.

December 13. — Patient is doing well. Pulse 96. Stump looks healthy, except on the inner side, where a portion of the slough is still adhering. The wound is twice a day syringed out, and dressed with lint, soaked in warm water. Small, outer ligature came loose. Ball was detected at the bottom of incision in leg, and taken out from between the deep muscles of calf.

December 14. — Patient continued well. Pulse 94. Stump granulating. Some swelling of foot, which is bandaged up to incision.

December 15. — Stump looks drier than usual and secretes duly a small portion of pus. No swelling or hardness. Pain in left shoulder, pulse 100, excited. Evening, rigors and alternate heat, followed by sweat and great prostration. Pain in superior jaw. To have quiniæ sulph. grs. v., every four hours. Cont. diet and wine.

December 16. — Pulse 104, weak. Stump still dry, a shade darker than before. No swelling, nor hardness. Leg is doing well. There is some pain in abdomen, especially in right iliac fossa, but no tumefaction nor tympanitis. To have quiniæ sulph. grs. v., every four hours. Evening, chill less severe than last night. There is great restlessness and pain in abdomen; had three watery discharges since afternoon. ℞ emuls. oleos. ʒj., morph. sulph. gr. i., one spoonful every hour or two. Warm fomentations to abdomen.

December 17. — Was delirious and had pain in abdomen all night. Extreme weakness; no discharge from bowels. Stump has the same appearance. Tongue inclined to become dry. There is fullness in præcordia and tympanitis. Pulse 120. The lower lobe of right lung presented signs of congestion. Dullness on percussion and some rare mucous rales. Left side, harsh puerile respiration. Prolonged expiration. A blister was applied to right side of chest. To have 4 grs. of citrate of iron and quinia every three hours, and some warm punch.

December 18. — Patient was feverish and delirious all night. Abdomen painful and tympanitic. Diaphragm pushed upward, respiration short and hurried. Dullness on percussion increased on right side; the rales also extend further upward. Left side presents a clear sound on percussion, and bronchial respiration. The tongue is furred, dry, and brownish in centre, but moist on edges. Pulse 124, fluttering. Stump discharges only a small amount of sero-purulent matter. Wound in leg almost closed.

December 19. — Died at ten o'clock last night of exhaustion.

December 20. — *Post-mortem Examination.* Rigor mortis well marked, body emaciated. Stump resembles dry pork; no sign of gangrene. Arteries and veins were found healthy. The cut extremity of the humerus presents a blackish appearance to extent of one half inch.

Knee-joint healthy. The ball had passed behind the outer condyle of femur and head of fibula down into the leg, where it lodged and was extracted as stated above.

Thorax. — Lower lobe of right lung conjested and partly hepatized. The posterior part of both lungs gorged with dark venous blood. The pulmonary veins filled with tough, cord-like clots of fibrine. Bronchial ramifications of both sides filled with a muco-purulent secretion. Heart flabby and pale. Right ventricle filled and soaked with blood.

Abdomen. — Liver enlarged and congested. Stomach largely distended with gas, and presenting numerous ecchymoses. The mucous lining of the whole intestinal canal had a dark venous color with ecchymoses here and there. No adhesions of the peritoneum, which was only partially congested. There were no intestinal ulcerations, and no enlarged intestinal glands or follicles. Spleen considerably enlarged, but without structural change. Kidneys of natural size and healthy. *Encephalon* not examined.

The report of the foregoing case was contributed by Dr. Phelps — Christian name and military rank not stated.

Comments. — This patient died four days after he was attacked with pyæmia, and inasmuch as the case appears not to have been complicated with the phenomena of thrombosis, at least so far as the causation of the pyæmia was concerned, it has been selected as the first in order of presentation to illustrate the structural lesions occasioned by this disease. The immediate cause of death appears to have been pyæmic pneumonia. There are several points connected with the morbid anatomy of this case which deserve special attention. They are *firstly* the *ecchymosed condition of the gastro-intestinal mucous membrane.* From rupture of capillary blood-vessels blood had been extrava- Rupture of capillary.

sated at numerous points in the lining membrane of the stomach and intestines, but more especially in that belonging to the former.

Again, the *stump* from whence sprung the disease was *dry and firm, presenting no inconsiderable resemblance to salt pork.* The blood-vessels of the stump were healthy; and the veins were even not obstructed with coagulated blood (thrombus).

The *lungs* were in a state of *active hyperæmia* (inflammation), and a considerable part of the lower lobe of the right organ had become solidified or hepatized through the agency of that process.

Wound nearly healed.

The wound located in the leg was nearly healed. The reparative process in it did not seem to have been interfered with by the pyæmic intoxication.

The clinical history of this case is here given in full, because it has been drawn up with unusual care by the surgeon who reported it.

POST-MORTEM OBSERVATIONS IN PYÆMIA.

CONTRIBUTED BY DR. ROBERTS BARTHOLOW.

CASE I. — Private Nathan Snyder, 100th Indiana Vols. Wounded in left popliteal space. (Probably November 25, 1863.)

Date of death, February 12, 1864. Date of autopsy, February 13. Aged 25. Height five feet eight inches; brown hair, blue eyes.

Rigor mortis, slight. Great emaciation. Both feet swollen. Cicatrix of original wound on internal surface of leg, immediately below the head of the tibia; another opening in the popliteal space posterior to the joint. Exploring the wound from site of original injury upward and downwards, the following condition of things is found to exist: from six inches below original wound to the pubes on the internal and posterior face of the limb, is the sac of an abscess, emptied of its fluid contents, but containing masses of decomposing areolar tissue of bluish-gray color, and cheesy masses (inspissated pus). The ball (conoidal) is found lodged against the ramus of the pubes. The inguinal glands of left side are much enlarged; they are brownish in color exteriorly, but on section are seen to have a yellowish central spot, much softer than the rest of the gland. Femoral vein pervious, but contains a small thrombus under Poupart's ligament. Another thrombus is found in iliac vein. Fibrine of these clots yellowish-white, indistinctly granular but not presenting the puriform character. The lymphatic glands along spinal column adjacent to the ascending cava, are very much enlarged, presenting the same appearance as the lymphatic glands.

Small purulent depots are found in both lungs, surrounded by dark consolidated lung tissue.

Substance of spleen remarkably firm; splenic pulp deficient; trabeculæ prominent; malpighian bodies, large and numerous.

Cortical substance of kidney yellowish-brown; pyramids of light-fawn color.

Brain moist and pale; no other peculiarity. Organs not mentioned, healthy.

Remarks. — The condition of the lymphatic system point to this as the source of the pyæmia. The thrombus in the femoral and iliac vein evidently did not furnish embolia. The enlargement of the iliac and lumbar glands, their brownish exterior, and the softening central yellow spot, indicate the absorption of morbific matter, whereby the poisoning of the blood was ultimately procured. The malpighian bodies of the spleen, indicate the same fact. Lymphatic system.

Looking to the condition of the wound — the putrefactive decomposition and the disengagement of the usual gaseous products — we have a solution of the state of the lymph and lymph-glands. It is to be remarked that the destructive process going on in the track of the ball, did not invade the areolar tissue in the vicinity of the popliteal and femoral vein.

Case II. — Private Amasa J. R. Worder, Company E, 42d Illinois Vols. Aged 26. Height five feet ten inches. Wounded November 25; died April 5. Gunshot fracture of thigh (middle third). An abscess occupies a space from margin of acetabulum to margin of lower third of femur, on the whole anterior aspect of limb.

(Condition of veins and lymphatic glands not stated.) Upon attempting to remove right lung, a large collection of extremely offensive pus was found to occupy the whole posterior surface of right cavity. The sac of the abscess was formed by the costal and pulmonary pleura, and was lined by an extremely tough membrane. The diaphragm was softened and broken down, so that the upper surface of the liver formed the inferior boundary of this collection of pus. The lung adjacent to abscess, was of greenish color; the inferior lobe contained a number small depots of pus.

Liver fawn color, tearing easily, and perceptibly fatty.

Spleen eight inches in long diameter by four and a half. A large portion of the organ broken down, forming a brown pultaceous mass, having a very offensive odor. Under microscope this pultaceous mass was seen to contain large compound nucleated corpuscles, broken and imperfect cells of various kinds, and granules.

Kidneys were soft and friable, of a light-fawn color. The pelvis of right filled with an immense number of small calculi, the largest three quarters of an inch in diameter.

Brain: eleven ounces of fluid in sub-arachnoid space.

Remarks. — Although the fact is not stated, this case was undoubtedly one of pyæmic poisoning through the lymphatic system, as the condition of the kidneys, spleen, and pleura clearly indicates.

Through lymphatic system.

Case III. Corporal Robert Shields, 4th Iowa Vols. Five feet nine and a half inches high; dark hair, black eyes: bronzing of face and upper extremities. Wounded at Ringgold, Ga., November 27. Leg amputated same day two inches below inferior border of patella. Died January 14, 1864.

Head of fibula protrudes through flap. End of tibia covered with large fungous granulations; bone soft, dark, and readily cut with a knife. Joint disorganized; articulating surfaces eroded; the anterior face of the thigh for a space of seven inches along the femur occupied with an abscess; bone denuded of periosteum. Tissues along abscess bluish-gray, sloughing and offensive. Pus thin, watery, containing masses of decomposing areolar tissue; few perfect pus cells; powerfully odorous.

The femoral and popliteal vein was bathed in this ichorous fluid, for a space of ten inches. Upon opening the vein carefully, the following appearances were observed: from Poupart's ligament to popliteal space the vein was filled with a firm thrombus, adhering especially at its upper part firmly to the lining. A soft venous coagulum extended up to cava. The upper portion of this thrombus consisted of a coagulum venous in character, beginning to soften in the centre; approaching the popliteal space it became paler, and finally of the color and consistence of cream or laudable pus. This last portion examined under the microscope, was seen to consist of granular matter, such as is described in Virchow's "Cellular Pathology." Although the thrombus adhered firmly to the lining membrane of the upper part of the vein, there was seen to be no lesion of the vessels, but the epithelial layer was as smooth as in health.

Inguinal, lumbar, and mesenteric glands much enlarged, and contained a central soft yellowish spot.

Spleen. — Eight and a half inches by four and a half inches. Malpighian bodies remarkable for their number and size; trabeculæ firm, and splenic pulp less in quantity than normal.

Left lung adherent by firm old adhesions to diaphragm. Various small depots of pus are found at various points, especially in inferior lobe of right lung. A careful search for embolia was made, but nothing answering to these was found, except coagula in the small veins of inferior lobe.

Other organs presented nothing abnormal.

Remarks. — This case answers to Virchow's doctrines of thrombosis. It might be considered a case of "mechanical pyæmia." It is possible that the depots in the lungs

"Mechanical pyæmia."

may have been formed by embolia, but of this there is no proof. Indeed, the autopsy proves just the contrary if it proves anything. The alterations in the lymphatic system were very pronounced.

Case IV. — Private Henry Knöbel, 149th N. Y. Vols., aged 27. Height five feet eight inches; dark complexion. Face and upper extremities bronzed. Wounded November 27, 1863. Died January 14, 1864.

Amputation of leg. Gangrene, following flesh wound of thigh. Cause: narrowing of femoral artery after injury to its external coat by the ball.

Autopsy. — Bones protruding. Femoral vein contains a thrombus closely attached to vessel under Poupart's ligaments. Lymphatics of groin enlarged. Depot of pus in superior lobe of left lung. Some ulcers in small intestine. Other organs healthy.

Case V. — Private W. Landcraft, 10th Missouri Vols. Wounded November 25, died January 19. Aged 24; five feet seven and a half inches high; brown hair and eyes; face bronzed. A gunshot wound of left shoulder; wound closed. Another six inches above external malleolus, left side, exit opposite; ball passed through other limb. Femoral and popliteal veins contain a large thrombus of a pale-pink color, and puriform in character; extends to Poupart's ligament. Inguinal glands enlarged; bluish and brownish exteriorly, and containing a central yellowish spot.

Lungs. — Abscess three inches by one inch in inferior lobe of left lung. Extensive recent adhesions of pulmonary and costal pleura on both sides. Twenty oz. fluid in cavity. Large fibrinous clots in all the cavities of the heart. Collections of pus were found also between base of right lung and diaphragm, and between middle and superior lobe of same lung. Also, between inferior lobe of left and diaphragm.

A large abscess was found in the limb, extending from head of tibia, six inches downward. The popliteal vein was encroached upon by this collection, but was not eroded.

Case VI. — Private William Hobbs, 22d Indiana Vols., six feet high; dark hair and eyes. Wounded November 25; died January 25.

Autopsy. — A sloughing wound in the right iliac region, five and a half inches in long diameter, nearly circular. A brownish discoloration of integument, especially of the shoulders, thorax, and face. Left inferior extremity much larger than the right. The inguinal glands are enlarged, and the tissues about them infiltrated with serum. Externally the glands are of a reddish-pink; internally contain a central whitish spot. From Poupart's ligament to middle third of thigh, the femoral vein contains a thrombus more or less attached to the wall of the vein, but which may be detached without impairing the integrity of the lining

membrane. The central portions of this clot are yellow, granular, and puriform. The same thrombus extends through the whole length of iliac vein. The heart cavities contain voluminous fibrine clots. A degree of fatty degeneration of the heart.

Lungs. — In superior lobe of left a dark brown patch, containing a small abscess. Vein leading to this patch contains a firm clot (embolus ?). In inferior lobe, several deposits of same character. Much larger depots are found in inferior lobe of right lung.

Liver. — Generally of a fawn color, breaking up readily, and perceptibly fatty.

Brain. — Wet.

An exploration of femoral vein of left side disclosed a large thrombus of a reddish-gray color, not however so puriform as that in the right.

Remarks. — The two last cases (Landcraft and Hobbs) illustrate Virchow's doctrines. The formation of a thrombus is due to local morbid processes; the secondary abscesses to the mechanical or chemical irritation, or both, of embolia detached from vein clot.

CASE VII.—Private Andrew J. Daniels, 25th Illinois Vols. Gunshot wound of elbow. Amputation, secondary. Received November 25, 1863; deceased, January 26, 1864.

Autopsy. — Light complexion, brown hair; height 5 feet 3 inches. Axillary and subclavian veins filled with a thrombus softening in the centre. Flaps not united; lined with a dark gray, pultaceous slough. Axillary glands enlarged, softened, and yellowish. Left side of thorax contained 4 oz. bloody serum.

Lungs. — Base of right lung fully adherent to diaphragm, and detached with difficulty; inferior lobe contains several small depots of pus. Same appearance in left.

Liver large, soft, and fatty.

CASE VIII. — Private W. J. Owens, 41st Alabama. Wounded 25th November. Died January 29. Aged 46; 5 feet 9 inches in height. Gunshot wound of dorsum of left foot, 1st metatarsal bone involved.

No thrombus in veins of this extremity. Inguinal glands large, soft, especially internally, breaking up readily under the finger into a diffluent mass.

Some ulcers in small intestine. Spleen very large and soft, breaking up so readily as not to be removed from abdomen without injury.

Other organs healthy, except larynx and epiglottis. Base of tongue much swollen; the circumvallate papillæ large and injected; epiglottis swollen and erect, and in its interior extending into base of tongue was an abscess containing laudable pus. Vocal chords thickened; exudation into connective tissue; and various depots of pus along the plane of the thyro-hyoid membrane.

Remarks. — This case was one of secondary abscess from blood-poisoning which occurred through the lymphatic system. Through lymphatic system.

Dr. Bartholow's valuable contribution containing the results obtained by post-mortem examination in eight cases of pyæmia, together with his remarks upon the same, has thus been given entire, that is without abbreviation or essential alteration.

On a superficial examination of the subject it might be supposed that the efficient cause of pyæmia consists of a low grade of lymphatic inflammation, but this would be a mistaken view of the matter; for, while it *is* unquestionably true that in cases of traumatic pyæmia the lymphatic vessels and lymphatic glands connected with the injured or suppurating part are very frequently found to be inflamed, it is also true that these vessels and glands are sometimes found to be not inflamed in undoubted cases of pyæmia. This circumstance shows conclusively that the occurrence of lymphatic inflammation is not essential to the production of pyæmia, and that the efficient cause of this disease must be sought for in other pathological conditions. But the lymphatic inflammation when present constitutes an important complication of pyæmia, more especially of its chronic forms, and probably assists not a little in inducing the *leucocytosis* of a marked character which usually attends those cases.

Summary. — The anatomical lesions which are met with in fatal cases of pyæmia may be briefly described as follows: 1st, Extravasations of blood in the nature of ecchymoses which occur principally in or beneath the mucous membranes. Anatomical lesions. 2d, The obstruction and even the occlusion of the veins running from the focus of infection (the place of local suppuration), with coagulated blood (thrombus), a circumstance which was formerly supposed to be due to inflammation of the lining membrane of such veins (phlebitis), but which is now known to be as a general thing entirely unconnected with the inflammatory process in the coats of the affected veins. 3d, Inflammation of the lymphatic vessels proceeding from the focus of infection denoted by an increase of their size and by tumefaction, reddening, serous infiltration, and suppuration of the glands connected with them. 4th, Visceral inflammations, to which the lungs are much more prone than any other organ. 5th, Membranous inflammations which are met with not unfrequently in the instances of the pleura, pericardium, and peri-

toneum. 6th, Rapidly formed collections of pus in the serous cavities and in the joints, the result of a low grade of inflammation, which are for the most part attended with little or no pain. 7th, Secondary visceral abcesses which are generally multiple, though occasionally single, and are formed both on the surface and in the parenchyma of various organs such as the lungs, liver, etc., being at the same time surrounded by inflamed parenchymatous tissue. 8th, Suddenly formed accumulations of pus in the intermuscular and subcutaneous connective tissue in various parts of the body, such as the axilla, iliac fossa, calf of the leg, etc., the tissues surrounding them being in a boggy and œdematous state.

Secondary abscesses.

The secondary visceral abscesses vary in size from that of a mustard-seed to a cherry or a plum; and in occasional instances they attain a much larger size. As already stated they are generally, but not always, multiple; and sometimes their number is so large that the affected organ is studded with them. When the surface of the lungs is disordered in this way these organs not unfrequently present a singularly pustulated appearance externally, each pustule being surrounded by a reddened areola of inflamed pulmonary tissue, which resembles in no slight degree the appearance presented by the skin when affected by distinct small-pox at the period of maturation. Secondary abscesses are found in the lungs more frequently than in any other organ. After the lungs they occur next in the order of frequency in the liver, next in the kidneys, next in the intermuscular connective tissue, and next in the joints. But pyæmic abscesses may occur in any other organ or part of the body. For example, they have been met with in the spleen, in the brain, in the prostate gland, in the uterus, in the testis, in the trachea, and in the heart. In the following case, the so-called metastatic or pyæmic abscesses were formed in the *larynx* and *epiglottis*. There were also secondary abscesses in the lungs and patches of lobular pneumonia. Death occurred suddenly from spasm of the glottis, as was to be expected from the nature of the disease and the locality of the purulent depots or the metastatic abscesses.

The report of the next case was contributed by Dr. A. B. Taylor, late Assistant Surgeon Indiana Volunteers.

Case XVIII. *Gunshot Wound of Foot; Pyæmic Symptoms developed on Fifty-seventh Day; Death suddenly produced by Suffocation Eight Days afterwards; Autopsy; Secondary Abscesses in Epiglottis and Larynx; Secondary Abscesses in Lungs; Bloody Serum in Pericardium; Liver soft-*

ened, and it has a Cicatrix on Right Lobe. — Wm. J. Owens, Private, Co. D, 41st Alabama Regiment, was admitted into General Field Hospital near Chattanooga, Tenn., on the 3d day of January, 1864, suffering from a gunshot wound of right foot, which was received at Charleston, Tenn., the 24th November, 1863. The ball entered near the first metatarso-phalangeal articulation, and passed out on plantar surface.

When admitted his general health was good and the wound was healing kindly; he continued to improve up to the 20th day of January, 1864, when he had a severe chill, followed by fever, with some difficulty in deglutition and respiration; the febrile symptoms subsided on a free use of anti-periodics. But the laryngeal symptoms continued the same up to the 24th, when he appeared to get better, and was able to go about the ward; on the afternoon of the 28th, while laying upon his bed, he was suddenly seized with symptoms of apnœa, and before any assistance could be rendered, he died.

Autopsy. — . . . . Epiglottis erect and much enlarged; *an abscess occupies nearly the whole of the interior of the organ.* It is filled with creamy pus. Mucous membrane of pharynx of pale-yellowish color, having patches of dirty-white exudation on its surface; its sub-mucous connective tissue is infiltrated with a serous fluid containing masses of exudation, undergoing degeneration. *Mucous membrane of larynx injected; and there are numerous small depots of pus in the connective tissue underneath that membrane.*

Great prominence and thickening of *papillæ circumvallatæ*, and distension of connective tissue about the base of tongue, where there are also some small abscesses.

Lungs. — Anterior surface of both lungs pink, mottled with patches of blue; crepitant; posteriorly red and purple; bloody serum exudes plentifully on section; *small depots of pus in inferior lobe of left lung*, around which the lung tissue is consolidated.

Heart. — Two ounces of serum in sac of pericardium, sac connected with diaphragm by old adhesions converted into adipose tissue; heart flaccid, cavities empty, large masses of fat along base of right ventricle; muscular walls of pale-purple color externally, deep-purple color internally.

Liver. — Cicatrix on anterior surface of right lobe, corresponding to a cicatrix in integument; substance of the organ of a deep-red color, soft, and easily broken up.

Spleen. — Six inches in length.

This case appears to be the same as that related by Dr. Bartholow as No. VIII., in his contribution, which we have just laid before the reader.

We do not propose to discuss in this place the connection which

has been supposed by the disciples of Virchow to exist between thrombosis and the formation of pyæmic abscesses; for it has not yet been satisfactorily shown that visceral abscesses to any considerable extent or in any considerable proportion of the cases are produced by thrombosis or by softening and detachment of venous coagula. On analyzing or critically examining the cases of pyæmia in which secondary abscesses occurred, that have been related in the foregoing pages, we find, 1st, that secondary abscesses are sometimes met with when thrombi cannot be found in the veins connected with the focus of infection nor elsewhere; and, 2d, that visceral (secondary) abscesses are not unfrequently met with in cases where the veins proceeding from the wounded part are filled up with *newly* coagulated blood (thrombus), the morbid process being obviously of an older date in the abscesses than in the veins. It is evident that in the first class of cases the visceral abscesses could not have been occasioned by thrombosis because it was not present, and in the second class of cases these abscesses could not have been produced by thrombosis, because the abscesses existed before the thrombi were formed.[1]

Virchow's theory.

Treatment. — The treatment of pyæmia is of the most unsatisfactory character. Let the surgeon do whatever he can, still nearly all (95 per cent.) of his patients affected with that disease, perish. Nevertheless, some do recover, and we have elsewhere narrated four successful cases, but they must be looked upon as happy exceptions to a usually fatal termination. The only plan of treatment which appears to hold out any reasonable prospect of success is the stimulating and tonic, or supporting one. There is one remedy which I have often found decidedly beneficial, namely, the sulphate of quinine. It does most good when administered in large doses, for example, ten grains four times a day. The preparations of iron, more especially the tincture of the sesquichloride, have also been found useful. For scorbutic cases the tartrate of iron and potassa will be preferable. Nutrients in the shape of milk, eggs, and beef-tea are demanded together with alcoholic stimulants in such quantity and such form as may be required to sustain the failing energies of the organism.

Sulphate of quinine.

[1] I am convinced from my own experience that the relation between thrombosis and pyæmia is not one of necessity, but on the contrary is quite accidental. 1st. Because I have seen a number of fatal instances of pyæmia with secondary abscesses, in which thrombosis was not present. 2d. Because I have often examined fatal cases of pyæmia in which the thrombosis was very recent, and had obviously occurred subsequent to the formation of the secondary abscesses; and, 3d, Because I have several times met with thrombosis unattended with pyæmia.

I have seen the tincture of the sesquichloride of iron administered with benefit in doses of twenty drops every four hours. The exhibition of anodynes is often required for the alleviation of pain, and to quiet restlessness. The pyæmic diarrhœa, especially when it occurs in chronic cases, is often relieved in a singular manner by the administration of the subnitrate of bismuth, in doses of ten or fifteen grains, three or four times a day. The nausea and vomiting which frequently prove to be very troublesome symptoms in cases of pyæmia may sometimes be allayed by the application of sinapisms to the epigastrium, and by the administration of cerii oxalat. in doses of grs. ij. to v., every four hours, in powder, when everything else has failed.

Sulphurous acid has been administered on theoretical grounds and with a view to obtain its *antizymotic* effects, but so far as I know it has never done any good in cases of pyæmia. The sulphite of soda, also has been used in these cases for the same reasons. In Professor Enos' case (No. XIV.), this remedy was administered in doses of fifteen grains, three times a day in solution, but without benefit. Indeed, I am not aware that it has ever proved at all useful to pyæmic patients. These remedies are mentioned here because their employment has been strongly urged on theoretical grounds.

The report of the next two cases was contributed by Dr. Charles A. Leale, late Acting Assistant Surgeon U. S. Army. In these cases also the sulphite of soda was given, but without effect on the disease.

Case XIX. *Secondary Amputation of Leg for Gunshot Wound of Ankle-joint with Fracture; Pyæmia; Death; no Autopsy.* — Clement Engelman, Adjutant 4th Pennsylvania Cav., aged 26, wounded at Dinwiddie Court House March 30th, 1865, by conoidal ball. Admitted April 4th, 1865, to Armory Square Hospital.

Diagnosis. — Gunshot wound of left ankle-joint. Ball passed through the joint, fracturing the tibia at its lower third.

When admitted had extensive suppuration; large abscesses had formed in foot and leg, which extended nearly to knee-joint. Had considerable febrile movement, no appetite, irregular and feeble pulse, with an occasional contraction of the buccinator muscles, resembling the commencement of tetanus.

Gave stimulants and beef-tea every hour.

April 19. — Leg amputated, at lower third of tibia, by "circular operation," by Dr. Bliss; took ether; stump dressed with lint and cold water.

Gave a stimulant — brandy ʒi. with morph. ¼ gr. in solution.

On examination the bones of the ankle were found badly fractured, and extensive abscesses had formed between the muscles of the foot.

Treatment, stimulants, beef-tea, anodynes. Had several chills each day with febrile movements following, due, apparently, to the introduction of the pyæmic poison into his system.

Gave quinine, sulphite of soda, stimulants, and beef-extract.

May 6. — Pus has collected in the knee-joint. I made first a valvular opening, but subsequently an incision about one inch in length at the most depending portion. Twelve ounces were discharged. The wound was kept open by the insertion of oakum. Gave patient one bottle of champagne each day.

May 12. — He died of pyæmia. No autopsy. His body was embalmed and sent home for interment.

Case XX. *Gunshot Fracture of Humerus (right) at Upper Third; Pyæmia supervened on Twentieth Day; Secondary Hemorrhage Thirteen Days afterwards; Controlled it with Styptics; Death; no Autopsy.* — Charles E. Pratt, Captain, Co. H, 10th N. Y. Cavalry, aged 26 years, wounded at Dinwiddie Court House, March 31st, 1865, by conoidal ball. Admitted, April 16th, 1865, to Armory Square Hospital, Ward F.

Diagnosis. — Gunshot wound of right arm. Ball entered opposite to the deltoid ridge, fractured the upper third of humerus, and made its exit at outer border of axillary space.

When he was admitted was very anæmic; considerable œdema near shoulder which extended to the elbow; pulse feeble; wound suppurates to a slight extent.

His arm was put up in splints and bandaged, after each orifice of the wound had been enlarged.

April 20. — Pyæmic symptoms commenced; had several chills during the day, each of which was followed by considerable febrile movement; yellowness of the conjunctiva perceptible.

Treatment, sulphite of soda, brandy, champagne, beef extract, and anodynes.

May 3. — Hemorrhage took place from the wounds, which commenced after a slough came away. Lost, about 8 oz. of blood. Hemorrhage arrested by styptics (liq. ferri persulph. fort.) Died — immediate cause, asthenia.

His body was taken to Elmira by his brother, who had attended him; was embalmed with chloride of zinc. No autopsy.

Comments. — The last two cases obviously belong to the same category as the vast majority of the cases of pyæmia which are met with in surgical practice, namely, upon wounds involving bone suppuration more or less extensive and unhealthy, or foul, supervenes, in this purulent matter the pyæmic poison is elaborated,

from this purulent matter or primary focus of infection the pyæmic poison is absorbed and diffused through the whole system, and thus, sooner or later, the symptoms of pyæmia are developed, and the structural lesions characteristic of the disease are produced. It is also probable that in both of these cases suppurative osteo-myelitis was present, and that the suppurating marrow in reality constituted the primary focus or source of the purulent infection. That suppurative osteo-myelitis of the stump-bone, the tibia, occurred in Case XIX., there is scarcely room for any doubt, since consecutive pyarthrosis of the knee occurred in a manner quite characteristic of such inflammation of the medullary tissue, as we have already shown in the Chapter on Osteo-myelitis. And I do not perceive any good reason for doubting that in Case XX. (the last) the gun-shot fracture of the humerus was followed by suppurative medullitis of that bone, which afterwards gave rise to the pyæmic intoxication or purulent infection. It is also probable that in both of these cases the osteo-myelitis was of a diffuse character.

As already stated, the *sulphite of soda* was given without result in both of these cases.

Again, with regard to the treatment of pyæmia the administration of *aconite* has been recommended by some French physicians. I also have prescribed this remedy a considerable number of times in this disease, but without deriving any benefit whatever from it, at least so far as I could see.

Will removal of the focus of infection, or the suppurating part, in cases of traumatic pyæmia, by amputation or any other operative procedure, save the patient after pyæmia has occurred? To this question a negative reply must generally be made.[1] However, after *pyæmoid* symptoms have made their appearance exarticulation of the diseased member has sometimes proved successful, as happened in Case XX. of Section Second, and in another case related to me by Dr. David P. Smith; and Prof. Fayrer, of Calcutta, has reamputated the thigh, at the hip-joint, in two cases of diffuse osteo-myelitis of the stump-bone, after pyæmic symptoms had distinctly appeared, and succeeded in saving one of them.[2]

Can the occurrence of pyæmia be anticipated and prevented, or, in other words, is pyæmia a preventable disease? To this question

[1] See Section Second, p. 441.

[2] See *Medical Times and Gazette*, London, November 9, 1867, pp. 483, 484.

we reply that doubtless it is to considerable extent a preventable disease ; as has been conclusively shown by the great abatements in the ravages of pyæmia and kindred disorders which, time and again of late years, have been effected by improvements in the construction, ventilation, and administration of hospitals, and by improvements in the medication, alimentation, and hygienic treatment generally, of their inmates. In a practical point of view this question of preventability is the most important topic connected with pyæmia. This disease is so uniformly fatal that our only hope of staying its ravages, in the present state of our knowledge, rests upon preventing its occurrence. Let us now inquire what we should do, so far as individual cases are concerned, to accomplish this purpose. We should try *first*, to prevent the development of pyæmia *de novo*, and *second*, to prevent the spread of the disease to fresh subjects after it has appeared, by obviating its various causes. Thus, if the subjects of wounds, or surgical operations, or abscesses are enfeebled by overwork, and insufficient food, as soldiers in the midst of active operations in the field are apt to become, they should be promptly sustained by the administration of suitable nutrients, tonics, and stimulants. If they are debilitated by scurvy, by malarial intoxication, or by any form of chronic disease, and thus predisposed to be attacked with pyæmia, they should promply receive treatment calculated to remedy the preëxisting morbid state. Furthermore, their wounds, ulcers, and abscesses should be kept empty of pus and thoroughly clean. A solution of phenol (carbolic or phenic acid), or of coal-tar creosote, in water, having a strength not greater than 1 part to 100, nor less than 1 part to 200, should be kept constantly applied to the suppurating surface for the purpose of arresting any tendency which the pus may have to take on, or undergo, such a putrefactive change as develops the pyæmic poison. Lastly, the candidates for surgical operations, if debilitated or broken down, should be suitably prepared for undergoing the operation by restoring them to a sound or healthy state, whenever the nature of their disorder permits the necessary delay, before they are subjected to the operation. Thus much concerning the attention which we should give to the personal condition of patients who are exposed to pyæmia.

The patient's surroundings or external relations should also be carefully attended to. His chamber or ward in hospital should be light, clean, spacious, and perfectly ventilated. The air should be pure and free from odors of every kind. The patient should not be exposed to the effluvia arising from filth of any sort. The over-

crowding of patients should be carefully avoided. The subjects of wounds, especially of those involving bone, should not be placed in hospitals already infected with the pyæmic poison. They should be placed in clean hospital tents, unless there is suitable accommodation for them in quarters which are uncontaminated and thus free from pyæmia peril. This is a matter which is too often overlooked, but at the same time is one of very great practical importance. Patients about to undergo surgical operations should not be taken to hospitals infected with pyæmia for the purpose of having them performed, because to treat them in such hospitals is tantamount to consigning most of them to inevitable death, when otherwise they might be saved. The importance of this point cannot well be exaggerated. When pyæmia breaks out in a hospital previously free from infection, the patients seized with this disease should immediately be isolated from the others, and the infected ward should have its floor, walls, and ceiling washed with a solution of phenol or coal-tar creosote. The ward should then be shut up for some time, or, if patients are allowed to occupy it, they should all be non-traumatic cases. By attending to these plain rules much may be done to prevent the development and arrest the spread of pyæmia.

Conclusions concerning Pyæmia. — From much clinical experience and from an attentive study of the subject I have been led to adopt the following conclusions concerning this disease : —

1st. Pyæmia is always connected with some local suppuration or its equivalent, that is, with some primary purulent depot, as the source of infection.

2d. These primary depots may be either traumatic or non-traumatic in respect to origin, but traumatic cases occur much more frequently than non-traumatic ones.

3d. Traumatic pyæmia in a very large majority of instances is connected with some lesion of bone.

4th. Purulent osteo-myelitis occasions pyæmia much more frequently than any other form of local suppuration, and it does so mainly because the pyæmic poison is absorbed from marrow abscesses much more readily than from any other class of abscesses.

5th. Pyæmia sometimes results from suppurative wounds of the blood-vessels, and in rare instances from suppurative lesions of the connective tissue.

6th. Pyæmia generally occurs between the fourth and twenty-third days after injury or operation, and thus corresponds exactly

with the period of secondary hemorrhage. It is met with but seldom, comparatively speaking, after the latter date.

7th. Pyæmia is either acute or chronic in its course and duration. It may destroy life in two or three days or not till the lapse of several weeks.

8th. Thrombosis is not essential to the production of pyæmia, or of the secondary abscesses of the lungs, liver, spleen, etc., or of the secondary serous inflammations, which characterize this disease.

9th. Inflammation of the lymphatic vessels and glands constitutes a very frequent and important complication of pyæmia, but its presence is not necessary or essential to the production of the disease.

10th. Pyæmia is a zymotic disease of septic character, and is closely allied to erysipelas and hospital gangrene.

11th. The predisposing causes of pyæmia are debility resulting from want and exposure, from scurvy, from malarial intoxication, and from chronic diseases in general.

12th. The exciting causes of pyæmia are bad hygienic conditions, such as "hospital air" and "overcrowding," effluvia from filth, neglected wounds, and putrescent suppuration.

13th. The efficient cause of pyæmia is a subtle poison, or contagium, of septic origin, which enters the circulation by absorption, and thus becomes disseminated through the whole organism.

14th. This poison, when diffused through the system by the circulating blood, exhibits a strong affinity or preference for certain organs and tissues in which it kindles inflammatory irritation, and thus produces the so-called metastatic or secondary abscesses, and the so-called pyæmic or secondary serous inflammations. Thus the pyæmic poison, in the affinity which it manifests for certain organs and tissues in preference to others, is analogous in its operation to the poison of small-pox, typhoid fever, glanders, plague, and infectious disease in general.

15th. Although pyæmia is a disease of septic origin, it is quite distinct from septæmia properly so called, such, for example, as the septæmia of traumatic gangrene, hospital gangrene, senile gangrene, etc.

16th. The prognosis in cases of pyæmia is always very bad. Almost all who are attacked with this disease, perish. But few recover.

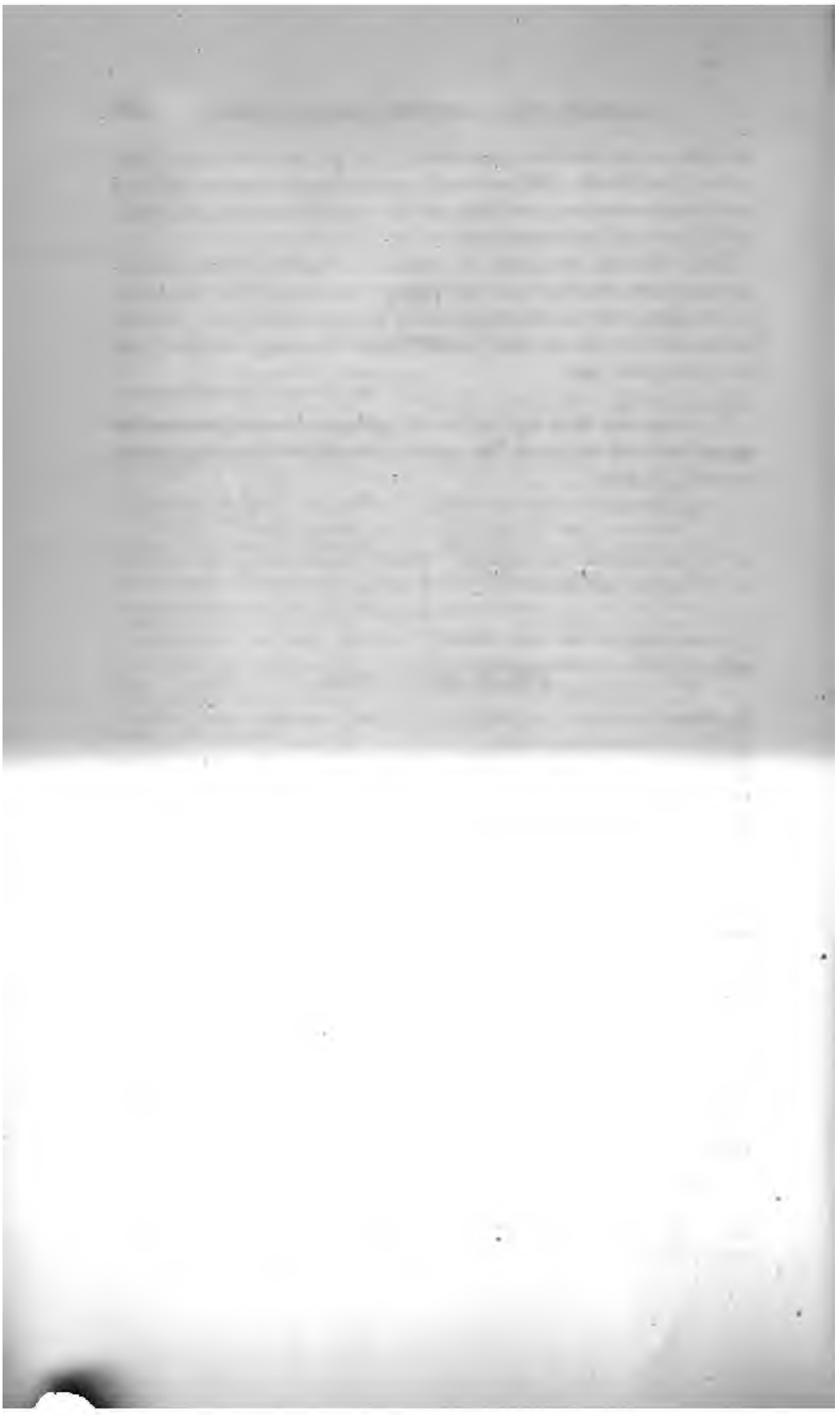
17th. Pyæmia requires a supporting plan of treatment. Quinine in doses of ten grains three or four times a day, and preparations

of iron with alcoholic stimulants, p. r. n., and nutrients, have proved beneficial. The oxalate of cerium has sometimes relieved the pyæmic vomiting, and bismuth the pyæmic diarrhœa, in a wonderful manner, in chronic cases.

18th. But the prevention of pyæmia is a matter of the most importance in a practical point of view. This should be attempted by obviating the predisposing causes, by neutralizing the exciting causes, and by placing the patient beyond the range of the pyæmic contagium itself.

Thus we see that the subject of pyæmia demands the earnest attention of all surgeons, but more especially of those engaged in hospital practice.

END OF SECTION THIRD.



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DR HAMILTON'S CASE OF OSTEO-MYELITIS AFTER OBLIQUE FRACTURE OF FEMUR.
LOWER FRAGMENT. CASE 10. DAVID DAFFORN.

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OSTEO-MYELITIS FIRST STAGE, GANGRENE OF MARROW, ABSCESS AND PERIOSTOSIS.

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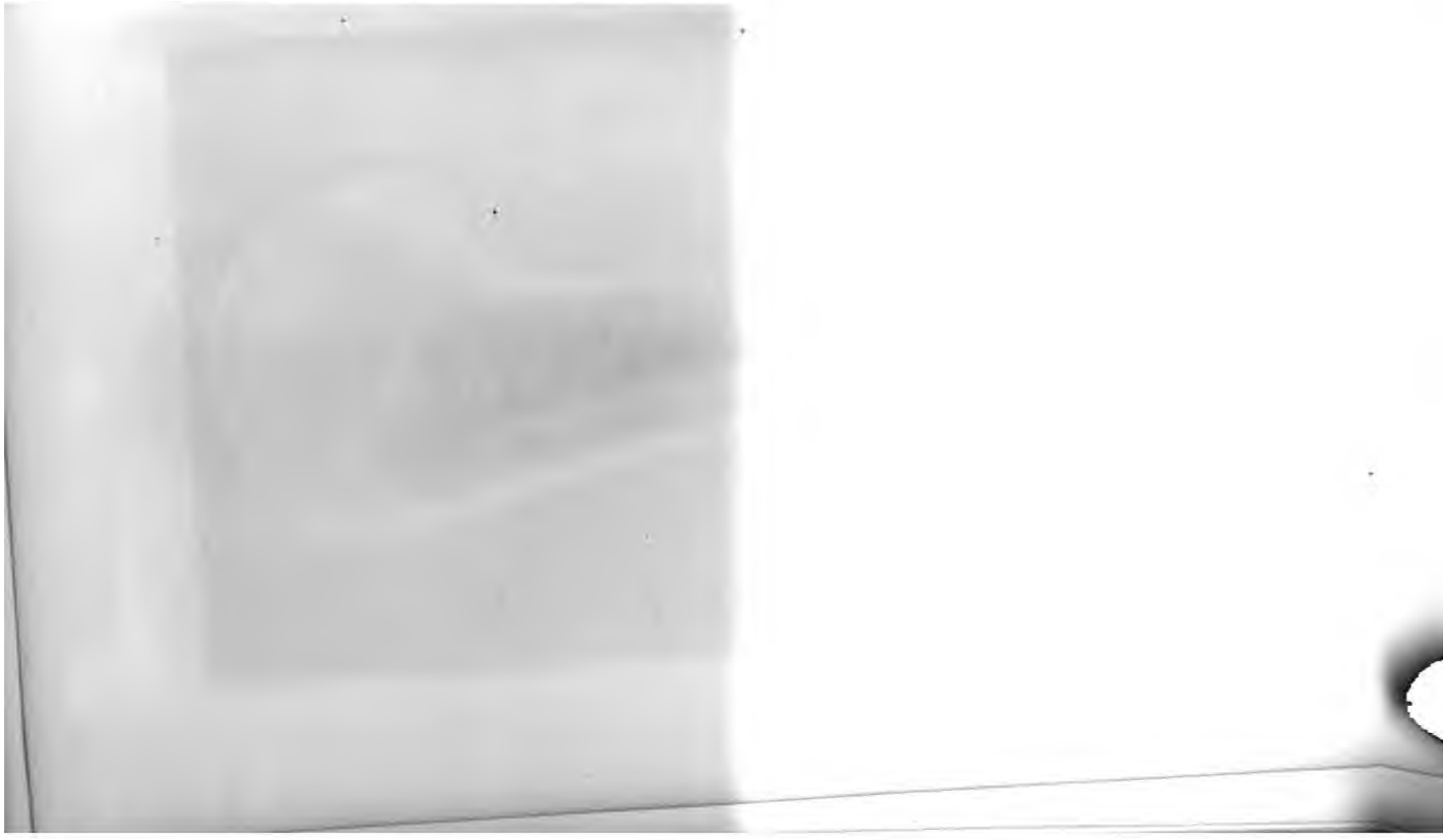

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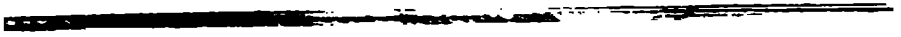

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